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A review of retractions at BioMed Central

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Abstract

Objectives

The objectives of this study were to assess why articles are retracted from BioMed Central journals and whether retraction notices adhered to the Committee on Publication Ethics (COPE) guidelines.

Design

Retrospective analysis of retractions from January 2000 – December 2014.

Results

77 retraction notices were published (constituting 0.04% of total articles [162,273]). A justification for each retraction was given. 56% of notices were written as being issued by the authors, 26% by the Editor(s) of the journals and 8% by the publisher. 10% of retraction notices did not state who had retracted the article. The most common reason for retraction was plagiarism (26%), followed by problems with the data (16%), lack of appropriate ethical approvals or permission to use data (13%), duplicate publication (10%), publication in error (9%), image manipulation (8%), and lack of awareness by some authors of the manuscript's submission (6%). 8% of retractions were due to data fabrication or compromised peer review process - reasons not seen before 2012. 4% were due to undeclared conflicts of interest. Almost half of retractions (47%) occurred because authors had committed some form of publishing misconduct.

Conclusions

COPE guidelines on retraction were adhered to in that an explicit reason for each retraction was given. However, some notices did not document who retracted the article and were ambiguous about the underlying cause (honest error or misconduct). Authors took responsibility for retracting articles when necessary, with the most common reason to retract being plagiarism. Retractions due to plagiarism may be reduced by screening manuscripts *before* publication although this is not guaranteed. Retractions due to problems with the data may be reduced by appropriate data sharing and deposition before publication. Adopting a checklist (linked to COPE guidelines) and templates for various classes of retraction notices would increase transparency of retraction notices in future.

Strengths and limitations of this study

- The first study to examine all retraction notices and the retraction patterns of a single publisher.
- The first study to examine quality of retraction notices and adherence to COPE guidelines by a single publisher.
- The conclusions drawn are limited by the number of retractions available to score during the time period of this study.

Introduction

Retracting an article is a decision not to be taken lightly. Retractions are a permanent means of correcting the scientific literature and necessary to alert the reader to serious problems identified with a published article. The Committee on Publication Ethics (COPE) have published guidelines on retraction in 2009 [1]. These guidelines advise on retracting articles if the main findings are found to be unreliable (either as a result of misconduct or honest error), redundant (i.e. previously published elsewhere in a citable format), or plagiarised (text or figures) or if the authors have reported unethical research or have failed to disclose a major competing interest which could influence the interpretation of the article.

Over the past few years there have been reports that most cases of retraction are attributable to misconduct [2], with a notable rise in cases of fraud [3]. More recently there have been retractions from several journals across different publishers due to systematic manipulation of the peer review processes by the provision of fabricated contact details for peer reviewers [4-6]. Calls continue for journals to be more transparent regarding their retraction procedures and explicit in their retraction notices [7-10] especially as retraction notices have been found to vary between, and within, journals [11-13]. Given this we analysed all retraction notices published between January 2000 and December 2014 to determine how consistent notices were in terms of reason for retraction and information provided, and how far they complied with the COPE guidelines for retractions. We report the findings here.

Methods

All retracted articles published between January 2000 and December 2014 were identified using the publisher's advanced search function [14] and 'retraction' as the article type. This time frame was selected because data were available across 14 complete years. Editorial 'expressions of concern'

were not included. Retractions were excluded if they were published by other publishers before the journal was transferred to BioMed Central.

Who issued the retraction notice, i.e. the author, editor, journal or publisher, and the reason for retraction were recorded. The time elapsed between publication of the original article and publication of the retraction notice was also recorded. Retractions were classified according to the apparent underlying motivation for the retraction i.e. honest error (mistakes on the part of the author or publisher) or research misconduct (data fabrication, failure to obtain ethical approval, failure to obtain permission for data) or publishing misconduct (plagiarism, duplicate publication, image duplication, authorship issues, compromised peer review) in line with previous studies [2] and using the definition of research misconduct given by [15]. Where it was not possible to distinguish 'honest error' from 'misconduct', the retraction notice was scored as 'unclear'. Where a retraction notice mentioned irregularities in the data and an institutional investigation the notice was scored as research misconduct unless honest error was explicitly mentioned.

Each retraction notice was classified by both authors independently using the information given in the retraction notice alone (i.e. no additional sources were used). Where there was a disagreement, a discussion took place to reach a consensus. Where multiple reasons for the retraction were given the main reason was scored and the secondary reasons were noted. The scoring of the retraction notices is given in Additional File 1.

Results

Between January 2000 and December 2014, our search identified 81 retraction notices. Four retraction notices were excluded because they were published by other publishers before the journal was transferred to BioMed Central (see Additional File 1).

Although our study suggests that retractions are on the rise, (Figure 1), proportionally there has been no increase when growth in the total number of articles published is accounted for. None of the retractions correlated with a particular journal, impact factor, article type or discipline within biology or medicine.

The majority of retraction notices stated that authors were responsible (56%), followed by Editor(s) (26%) and publisher (8%). No cases were recorded where the authors' institution issued a retraction. While the majority of retractions declared who was retracting the article, 10% of retraction notices

did not explicitly state this information (Figure 2), although it was implied that the notice was coming from the authors.

A more detailed breakdown of the reasons for retraction is given in Figure 3. The most common reason is plagiarism (26%), followed by problems with the data - i.e. the data was found to be 'unreliable' (16%), lack of appropriate ethical approvals or permission to use data (13%), duplicate publication (10%), publication in error (9%), image manipulation (8%), or because a lack of awareness by some authors of the manuscript's submission and publication (6%). 8% of retractions were due to data fabrication or compromised peer review process - reasons that were not seen before 2012. 4% of retractions were due to undeclared conflicts of interest either by the author (for example [16]) or by the reviewer (for example [17]) . Not all retractions occurred for a single reason. In 12 cases of retraction there were two reasons (for example, [18, 19]] and in one case three reasons were given [20]. However, for the purpose of this analysis the main reason was scored.

Most retractions originated due to some form of publishing misconduct (Figure 4) of which plagiarism was the most frequent.

The average time between publication of the article and its retraction was 422 days. Cases involving apparent misconduct took on average longer to retract (522 days) than honest error (194 days).

Discussion

COPE recommend that retraction notices provide adequate information so that readers know *who* is retracting the article and *why* the findings are considered unreliable, while clearly distinguishing forms of misconduct from honest error. However, retraction notices must strike a balance between providing adequate information without being defamatory or libellous. In many cases, retraction statements tend to be factual while lacking detail to avoid implying anything about the author's motivations for their actions [21].

Quality of retraction notices

In line with COPE guidelines [1] all notices of retraction were clearly identified as retractions and linked to the retracted article. During the time frame of this study (2000-2014), retractions were overseen by the publisher's in-house Biology or Medical Editor (although the individuals occupying these roles varied over the years). Oversight by internal staff ensured that a reason for each

retraction was always given and it was generally possible to classify retractions into discrete categories (plagiarism, duplicate publication, data fabrication, etc.). However, in some cases the descriptions given in retraction notices were ambiguous. For example, the stated reason for one retraction [20] was 'published in error' although the notice alludes to other problems with the data. 10% of notices did not state clearly who was retracting the article. In these notices, it was *implied*, but not explicitly stated, that the retraction was from the authors. These cases all occurred after the publication of the COPE guidelines on retraction.

Retractions due to authorship disputes are not recommended by COPE [1]. If the scientific integrity of the article is not affected, then it should be possible to resolve the issue by other means (for example by publishing a correction). In 6% of cases, retractions occurred because not all authors had been aware of the manuscript submission. However, these cases were all prior to 2009 before the COPE guidelines were formulated. Retracting solely due to a lack of awareness or agreement on behalf of all authors has not occurred since 2009 and COPE guidelines have been adhered to in this respect.

In order to further improve the quality of retraction notices BioMed Central now uses an internal checklist capturing the main information required in a retraction notice along with template wording. Others are also working on standard retraction forms to improve the consistency of retraction notices [8, 9]. It will be useful to take the findings presented here as a baseline for reviewing subsequent retraction notices in future.

Reasons for retraction

Plagiarism was found to be the main reason for retraction (Figure 1) as noted in [2]. The rise in software to detect plagiarism alongside development of sophisticated approaches to check figure manipulation [22] has gone hand-in-hand with a rise in retractions due to plagiarism in recent years [11]. While the use of anti-plagiarism software before publication may prevent the occurrence of retractions due to plagiarism in future, unfortunately there is a growing trend for authors to hide the evidence of plagiarism: for example, by substituting key words in the plagiarised text for words with the same meaning (Moylan personal observation). Therefore, even with sophisticated software tools, detecting plagiarism can be difficult; the pattern of citations rather than the exact text used often reveals that plagiarism has occurred. Peer reviewers frequently detect disguised plagiarism more accurately than software programmes given their familiarity with previously published literature.

The second main reason for retraction was that the published data has subsequently been found to be unreliable in some way. 20% of retractions were due to problems with the data. Often these issues occurred through honest error in how the data were handled (for example [23, 24] although in some cases it is difficult to determine whether honest error or research misconduct was the cause. Recent initiatives towards increased transparency and reproducible research through encouraging sharing and deposition of data prior to publication [25-27] should have an impact on reducing instances of retraction due to errors with the data in future. In making data publication-ready many issues may be caught and fixed before publication.

Retractions due to research misconduct also occurred but these were in the minority. In some cases notices were transparent (for example [28]), in other cases less so. Several retractions were due to lack of appropriate ethical approvals (6%) or permission to use data (6%).

Seven retractions recorded were due to articles being published in error (9%). In some cases, authors had withdrawn their manuscript in order to publish elsewhere but the manuscript had been transferred to the journal's production department, which resulted in its being published in error (for example [29]). Other cases occurred when a journal was transferring from another publisher and during this period an article was inadvertently published twice. Sometimes notices were explicit about what had happened (for example [30]) but sometimes they were cryptic (for example [31, 32]).

The majority of notices were issued by the authors (56%), in line with the findings of other larger studies (12, 33] because of publishing misconduct. Authors are taking responsibility for retracting articles when necessary even if they are not the party who flagged the problem originally. In 18% of notices it was not possible to distinguish the underlying issue which ultimately led to retraction: i.e. honest error or misconduct. This may reflect an author being cryptic about what actually happened or an Editor being judicious to avoid making potentially libellous comments. In other cases, an Editor may simply have not been able to uncover the real motivation for the author's actions.

Rise in research and publishing misconduct

In recent years, BioMed Central has seen an increase in retractions due to data fabrication and a compromised peer review process. Although this occurred in only 5% of cases within the time frame of this study (with one case of compromised peer review and three cases of data fabrication), early 2015 saw an increase in retractions due to the use of author-suggested fabricated peer reviewers, which compromised the peer review process [5, 6]. Other publishers may also issue retractions as a

result. These retraction notices were not included because they occurred outside of the time frame in this present study and would also have distorted the findings of the preceding ten years.

It is difficult to pinpoint measures that Editors can take to detect fraudulent and unethical practices *before* publication or even prevent them happening at all. At present, Editors and Publishers can put policies in place to encourage explicit author contributions, declaration of conflicts of interests (for authors and reviewers) and data sharing. They can also check for adherence to reporting guidelines and ensure the correct ethical approvals and permissions to publish data were obtained. Plagiarism checks (of text and figures) are becoming more frequent. Most recently, the BMJ introduced a 'transparency declaration', required of the lead author [34]. Where trust in peer review is abused (i.e. authors suggesting fabricated peer reviewers on submission of their manuscript) publishers have responded by taking a pragmatic decision to remove these facilities [35-37].

The decision to act unethically rests with the researcher [38]. But the tremendous pressures that continue to be placed on researchers to 'publish or perish' (outlined from a UK perspective in a recent report on the research culture in the UK [39] and reiterated in the Leiden manifesto [40] may actually encourage misconduct to 'cheat the system'. Clearly, there is a real need for awareness at all levels [38], from those in research to those making decisions on manuscripts (peer reviewers, Editors).

Conclusions

In summary, we found that COPE guidelines on retraction were adhered to in that an explicit reason for retraction was given in all cases of retraction evaluated from 2000-2014. However, in some cases notices did not document who issued the notice and there were ambiguities as to the underlying cause (honest error or misconduct). In future, adopting a checklist (linking to COPE guidelines) and a standard template for various classes of retraction notices would facilitate increased transparency and consistency of retraction notices.

Authors took responsibility for retracting articles when necessary, with the most common reason to retract an article being plagiarism. Although increasingly more and more journals are adopting plagiarism screening before publication this is by no means guaranteed to uncover all cases of disguised plagiarism. Retractions due to problems with the data (including fraud) are difficult to prevent, but data sharing and data deposition prior to publication should help address this.

Authors' contributions

ECM and MK collated and independently classified the data. MK analysed the data. EM wrote the first draft and revised the text. Both authors contributed to the writing of the manuscript and approved the final version.

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Competing interests

Both authors have completed the ICMJE uniform disclosure form and declare we are employed by BioMed Central. We declare no other relationships or activities that could appear to have influenced the submitted work.

Data sharing

The data set is provided in Additional File 1.

Transparency

The lead author (the manuscript's guarantor) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Figures

Figure 1. Growth in retractions and variation in reasons for retracting articles from 2000 – 2014. Plagiarism occurred as a reason for retraction from 2010 onwards when use of plagiarism detection software became more widespread.

Figure 2. Retractions grouped by who issued the retraction notice. The majority of retraction notices were issued by authors, however, in some cases retraction notices did not explicitly state who retracted the article. Numbers indicate total numbers of articles for each category.

Figure 3. Reasons for retraction from 2000 – 2014. Plagiarism was the most prevalent cause of retraction followed by problems subsequently identified with the data and duplicate publication. Numbers indicate total numbers of articles for each category.

Figure 4. Underlying cause of retraction. The majority of retractions originated due to publishing misconduct (plagiarism, duplicate publication, image duplication, co-authors unaware of submission, or compromised peer review). Research misconduct includes data fabrication, failure to obtain ethical approval, and failure to obtain permission for data. Numbers indicate total numbers of articles for each category.

Additional files

Additional file 1. Data set of retractions.

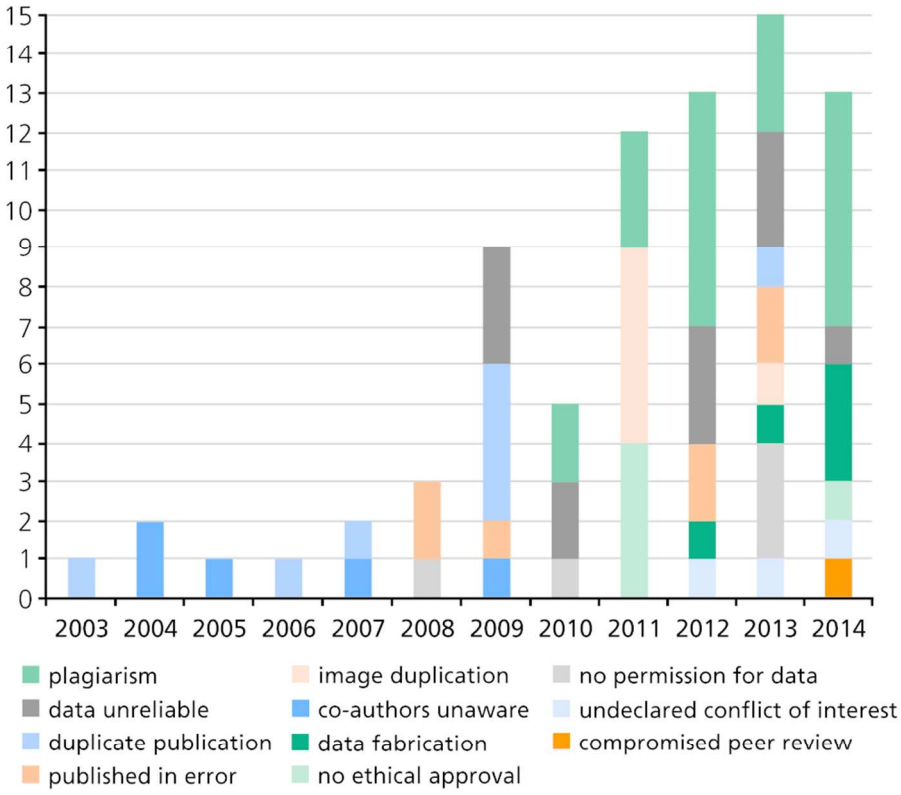

Figure 1. Growth in retractions and variation in reasons for retracting articles from 2000 – 2014. Plagiarism occurred as a reason for retraction from 2010 onwards when use of plagiarism detection software became more widespread.
93x83mm (300 x 300 DPI)

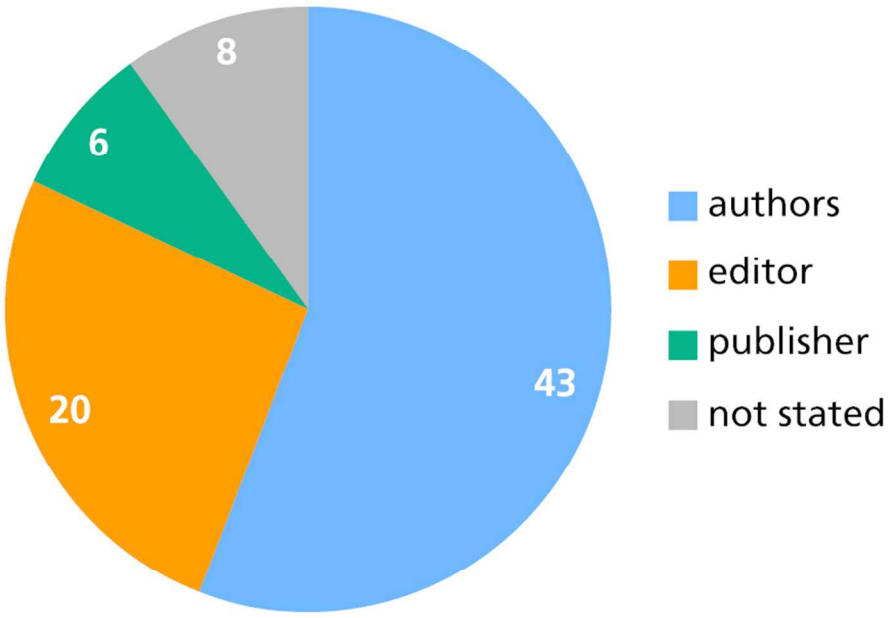

Figure 2. Retractions grouped by who issued the retraction notice. The majority of retraction notices were issued by authors, however, in some cases retraction notices did not explicitly state who retracted the article. Numbers indicate total numbers of articles for each category.
82x60mm (300 x 300 DPI)

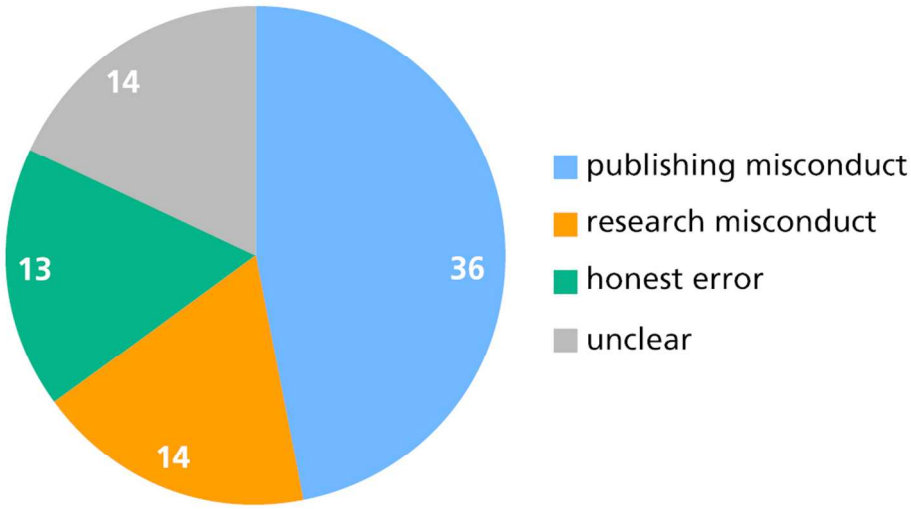

Figure 3. Reasons for retraction from 2000 – 2014. Plagiarism was the most prevalent cause of retraction followed by problems subsequently identified with the data and duplicate publication. Numbers indicate total numbers of articles for each category.
100x60mm (300 x 300 DPI)

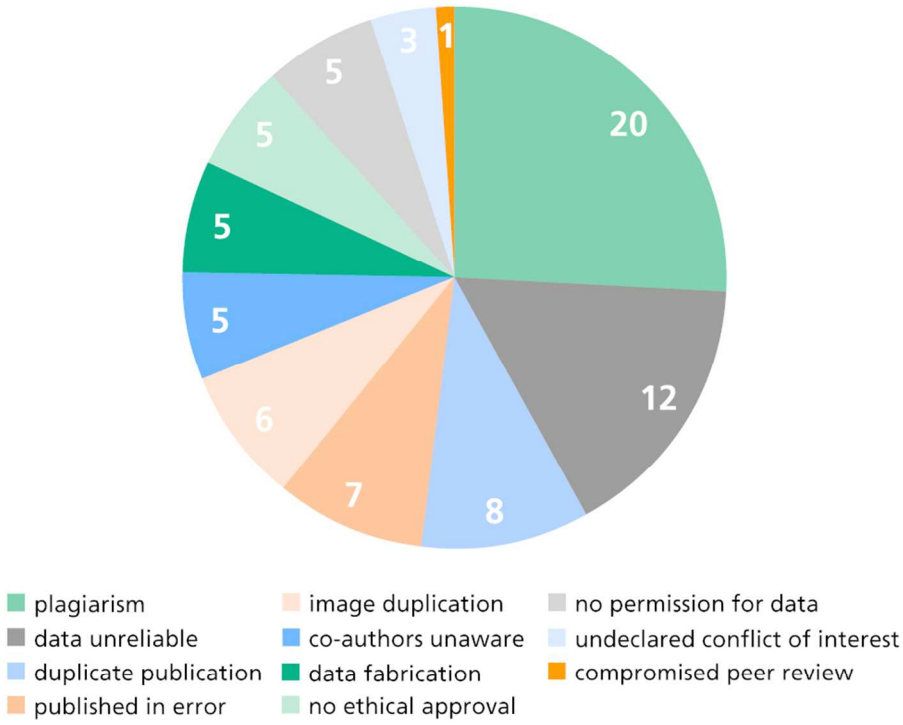

Figure 4. Underlying cause of retraction. The majority of retractions originated due to publishing misconduct (plagiarism, duplicate publication, image duplication, co-authors unaware of submission, or compromised peer review). Research misconduct includes data fabrication, failure to obtain ethical approval, and failure to obtain permission for data. Numbers indicate total numbers of articles for each category.
91x75mm (300 x 300 DPI)

link to retraction notice	Reason for retraction
http://www.biomedcentral.com/1756-0500/7/868	no ethical approval
http://www.annals-general-psychiatry.com/content/13/1/30	plagiarism
http://www.translationalneurodegeneration.com/content/3/1/22	undeclared conflict of interest. This w
http://www.nutritionandmetabolism.com/content/11/1/43	plagiarism
http://www.biomedcentral.com/1752-0509/8/105	compromised peer review
http://www.biomedcentral.com/1471-2393/14/202	data unreliable
http://www.dmsjournal.com/content/6/1/60	plagiarism
http://www.dmsjournal.com/content/6/1/59	plagiarism
http://www.molecularpain.com/content/10/1/20	data fabrication
http://www.ijponline.net/content/40/1/9	plagiarism
http://www.nutritionandmetabolism.com/content/11/1/11	plagiarism
http://www.retrovirology.com/content/11/1/16/abstract	data fabrication
http://www.biomedcentral.com/1472-6793/13/13	data fabrication
http://www.biomedical-engineering-online.com/content/12/1/113	image duplication
http://www.cancerci.com/content/13/1/96	data unreliable
http://www.biomedcentral.com/1756-0500/6/422	no permission for data
http://www.biomedcentral.com/1756-0500/6/332	data unreliable
http://www.diagnosticpathology.org/content/8/1/127	plagiarism
http://www.aacijournal.com/content/9/1/28	no permission for data
http://www.biomedcentral.com/1472-6750/13/57	data fabrication
http://www.skeletalmusclejournal.com/content/3/1/15	data unreliable
http://www.translational-medicine.com/content/11/1/144	published in error
http://www.biomedcentral.com/1472-6963/13/180	no permission for data
http://link.springer.com/article/10.1186/1559-4106-8-11/fulltext.htn	data unreliable
http://www.jdmdonline.com/content/12/1/21	published in error
http://www.scoliosisjournal.com/content/8/1/7	undeclared conflict of interest
http://www.proteomesci.com/content/11/1/16	plagiarism
http://www.jdmdonline.com/content/11/1/21	duplicate publication
http://www.jasbsci.com/content/4/1/3	plagiarism
http://www.biomedcentral.com/1472-6882/12/206	plagiarism
http://breast-cancer-research.com/content/14/5/402	data unreliable
http://www.gvt-journal.com/content/10/1/10	undeclared conflict of interest
http://journal.chemistrycentral.com/content/6/1/121	no permission for data
http://www.jnanobiotechnology.com/content/10/1/40	plagiarism
http://www.wjso.com/content/10/1/196	plagiarism
http://www.molecular-cancer.com/content/11/1/57	plagiarism
http://journal.chemistrycentral.com/content/6/1/72	plagiarism
http://www.biomedcentral.com/1471-2121/13/17	plagiarism
http://www.biomedcentral.com/1756-0500/5/319	published in error
http://www.celldiv.com/content/7/1/15	plagiarism
http://www.ctajournal.com/content/2/1/6	data unreliable
http://www.jeccr.com/content/31/1/21	data unreliable
http://www.cardiothoracicsurgery.org/content/7/1/17	published in error
http://www.biomedcentral.com/1471-2172/13/3	data fabrication
http://www.retrovirology.com/content/8/1/88	image duplication
http://www.wjso.com/content/9/1/136	plagiarism

http://www.eurjmedres.com/content/16/10/II	data unreliable
http://www.chiromt.com/content/19/1/24	no ethical approval
http://www.biomedcentral.com/1746-6148/7/56	plagiarism
http://www.biomedcentral.com/1471-2474/12/200	no ethical approval
http://www.biomedcentral.com/1471-2474/12/158	no ethical approval
http://www.biomedcentral.com/1471-2474/12/159	no ethical approval
http://www.biomedcentral.com/1471-2164/12/284	image duplication
http://www.biomedcentral.com/1471-2180/11/128	image duplication
http://www.biomedcentral.com/1471-2180/11/127	image duplication
http://www.jeccr.com/content/30/1/19	plagiarism
http://www.retrovirology.com/content/8/1/1	image duplication
http://www.biomedcentral.com/1472-6939/11/20	plagiarism
http://www.parasitesandvectors.com/content/3/1/78	data unreliable
http://www.virologyj.com/content/7/1/190	data unreliable
http://www.biomedcentral.com/1471-2105/11/258	plagiarism
http://www.cmjournal.org/content/5/1/10	no permission for data
www.jmedicalcasereports.com/content/3/1/122	published in error
http://www.molecularneurodegeneration.com/content/4/1/45	data unreliable
http://www.biomedcentral.com/1472-6947/9/45	data unreliable
www.microbialcellfactories.com/content/8/1/52	duplicate publication
http://www.molecular-cancer.com/content/8/1/84	duplicate publication
http://www.jeccr.com/content/28/1/137	duplicate publication
http://www.jeccr.com/content/28/1/101	duplicate publication
http://www.issoonline.com/content/6/1/11	author disagreement
http://www.hqlo.com/content/7/1/34	data unreliable
http://www.biomedcentral.com/1471-2342/8/15	no permission for data
http://www.jautoimdis.com/content/5/1/5	published in error
http://www.carcinogenesis.com/article.asp?issn=1477-3163;year=20	published in error
http://www.virologyj.com/content/4/1/119	author disagreement
http://www.josr-online.com/content/2/1/6	duplicate publication
http://www.cardiovascularultrasound.com/content/4/1/42	duplicate publication
http://www.molecular-cancer.com/content/4/1/17	author disagreement
http://www.molecular-cancer.com/content/3/1/1	author disagreement
http://www.molecular-cancer.com/content/3/1/2	author disagreement
http://www.molecular-cancer.com/content/2/1/17	duplicate publication

Published by?	Journal	Who retracted?	date retraction posted
BMC	*BMC Research Notes*	editor	11/25/2014
BMC	*Annals of General Psychiatry*	authors	11/26/2014
BMC	*Translational Neurodegeneration*	Editor	10/3/2014
BMC	*Nutrition & Metabolism*	editor	9/24/2014
BMC	*BMC Systems Biology*	editor	9/18/2014
BMC	*BMC Pregnancy and Childbirth*	authors	7/3/2014
BMC	*Diabetology & Metabolic Syndrome*	editor	5/27/2014
BMC	*Diabetology & Metabolic Syndrome*	editor	5/27/2014
BMC	*Molecular Pain*	authors	4/2/2014
BMC	*Italian Journal of Pediatrics*	authors	3/11/2014
BMC	*Nutrition & Metabolism*	editor	2/14/2014
BMC	*Retrovirology*	authors	2/6/2014
BMC	*BMC Physiology*	authors	1/10/2014
BMC	*BioMedical Engineering OnLine*	publisher	12/6/2013
BMC	*Cancer Cell International*	authors	10/22/2013
BMC	*BMC Research Notes*	editor	10/18/2013
BMC	*BMC Research Notes*	authors	8/20/2013
BMC	*Diagnostic Pathology*	authors	8/14/2013
BMC	*Allergy, Asthma & Clinical Immunology*	authors	8/12/2013
BMC	*BMC Biotechnology*	authors	7/20/2013
BMC	*Skeletal Muscle*	authors	7/18/2013
BMC	*Journal of Translational Medicine*	publisher	6/11/2013
BMC	*BMC Health Services Research*	authors	5/20/2013
Springer	*Biointerphases*	authors	5/16/2013
BMC	*Journal of Diabetes & Metabolic Disorde*	publisher	5/14/2013
BMC	*Scoliosis*	editor	5/3/2013
BMC	*Proteome Science*	editor	4/23/2013
BMC	*Journal of Diabetes & Metabolic Disorde*	not stated	3/7/2013
BMC	*Journal of Animal Science and Biotechnc*	authors	1/23/2013
BMC	*BMC Complementary and Alternative M*	editor	11/2/2012
BMC	*Breast Cancer Research*	authors	10/31/2012
BMC	*Genetic Vaccines and Therapy*	editor	10/23/2012
Chemistry Central	*Chemistry Central Journal*	authors	10/22/2012
BMC	*Journal of Nanobiotechnology*	not stated	10/4/2012
BMC	*World Journal of Surgical Oncology*	authors	9/20/2012
BMC	*Molecular Cancer*	authors	8/20/2012
Chemistry Central	*Chemistry Central Journal*	not stated	7/24/2012
BMC	*BMC Cell Biology*	editor	6/26/2012
BMC	*BMC Research Notes*	editor	6/21/2012
BMC	*Cell Division*	not stated	5/15/2012
BMC	*Clinical and Translational Allergy*	authors	3/16/2012
BMC	*Journal of Experimental & Clinical Cance*	authors	3/13/2012
BMC	*Journal of Cardiothoracic Surgery*	editor	3/6/2012
BMC	*BMC Immunology*	authors	1/16/2012
BMC	*Retrovirology*	authors	11/5/2011
BMC	*World Journal of Surgical Oncology*	authors	10/24/2011

Holzapfel Publishe	*European Journal of Medical Research*	authors	10/10/2011
BMC	*Chiropractic & Manual Therapies*	not stated	10/3/2011
BMC	*BMC Veterinary Research*	authors	9/20/2011
BMC	*BMC Musculoskeletal Disorders*	not stated	9/13/2011
BMC	*BMC Musculoskeletal Disorders*	not stated	7/13/2011
BMC	*BMC Musculoskeletal Disorders*	not stated	7/13/2011
BMC	*BMC Genomics*	authors	6/2/2011
BMC	*BMC Microbiology*	editor	6/2/2011
BMC	*BMC Microbiology*	editor	6/2/2011
BMC	*Journal of Experimental & Clinical Cance*	authors	2/16/2011
BMC	*Retrovirology*	authors	1/6/2011
BMC	*BMC Medical Ethics*	authors	12/21/2010
BMC	*Parasites & Vectors*	editor	8/25/2010
BMC	*Virology Journal*	editor	8/13/2010
BMC	*BMC Bioinformatics*	not stated	5/18/2010
BMC	*Chinese Medicine*	authors	3/16/2010
BMC	*Journal of Medical Case Reports*	publisher	11/13/2009
BMC	*Molecular Neurodegeneration*	authors	11/4/2009
BMC	*BMC Medical Informatics and Decision M*	editor	10/20/2009
BMC	*Microbial Cell Factories*	authors	10/15/2009
BMC	*Molecular Cancer*	authors	10/14/2009
BMC	*Journal of Experimental & Clinical Cance*	authors	10/9/2009
BMC	*Journal of Experimental & Clinical Cance*	authors	7/16/2009
BMC	*International Seminars in Surgical Oncol*	authors	4/17/2009
BMC	*Health and Quality of Life Outcomes*	authors	4/17/2009
BMC	*BMC Medical Imaging*	authors	8/11/2008
BMC	*Journal of Autoimmune Diseases*	publisher	8/11/2008
BMC	*Journal of Carcinogenesis*	publisher	8/8/2008
BMC	*Virology Journal*	authors	10/31/2007
BMC	*Journal of Orthopaedic Surgery and Rese*	authors	4/4/2007
BMC	*Cardiovascular Ultrasound*	authors	11/8/2006
BMC	*Molecular Cancer*	authors	5/6/2005
BMC	*Molecular Cancer*	authors	1/14/2004
BMC	*Molecular Cancer*	authors	1/14/2004
BMC	*Molecular Cancer*	authors	3/3/2003

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Why articles are retracted: a review of retraction notices at BioMed Central

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Why articles are retracted: a review of retraction notices at BioMed Central

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Key words retraction, plagiarism, data, publishing misconduct, research misconduct, fraud, retraction guidelines, peer review

Abstract

Objectives

To assess why articles are retracted from BioMed Central journals, whether retraction notices adhered to the Committee on Publication Ethics (COPE) guidelines, and are becoming more frequent.

Design

Retrospective analysis of retractions from January 2000 – December 2015.

Results

134 retraction notices were published during this timeframe. Although they account for 0.07% of all articles published, the rate of retraction is rising. COPE guidelines on retraction were adhered to in that an explicit reason for each retraction was given. However, some notices did not document who retracted the article (6%) and were unclear whether the underlying cause was honest error or misconduct (11%). The largest proportion of notices were issued by the authors (35%). The majority of retractions occurred because authors committed some form of publishing misconduct (62%). Among the most common reasons within this category were compromised peer review (33%), plagiarism (16%) and problems with the data (10%). Research misconduct accounted for 14% of retractions, of which 7% were due to data falsification or fabrication. Honest error accounted for 13% of all retractions, of which 10% were due to problems with the data. Median number of days from publication to retraction was 337.5.

Conclusions

The most common reason to retract was compromised peer review. However, the majority of these cases date back to March 2015 and appear to be the result of a systematic attempt to manipulate peer review across several publishers. Retractions due to plagiarism account for the second largest category and may be reduced by screening manuscripts *before* publication although this is not guaranteed. Retractions due to problems with the data may be reduced by appropriate data sharing and deposition before publication. Adopting a checklist (linked to COPE guidelines) and templates for various classes of retraction notices would increase transparency of retraction notices in future.

Strengths and limitations of this study

- The first study to examine all BioMed Central retraction notices and the retraction patterns of a single publisher.
- The first study to examine transparency of retraction notices and adherence to COPE guidelines by a single publisher.
- The study is limited by the number of retractions available to score and any correlations with a particular journal, article type, discipline or peer review model have not been explored.

Introduction

Retractions are a permanent means of maintaining the integrity of the scientific literature and necessary to alert the reader to serious problems identified with a published article. The Committee on Publication Ethics (COPE) published guidelines on retraction in 2009 [1]. These guidelines advise on retracting articles if the main findings are found to be unreliable (either as a result of misconduct or honest error), redundant (i.e. previously published elsewhere in a citable format), plagiarised (text or figures) or if the authors have reported unethical research or failed to disclose a major competing interest which could influence the interpretation of the article.

COPE recommends that retraction notices provide adequate information so that readers know *who* is retracting the article and *why* the findings are considered unreliable, while clearly distinguishing forms of misconduct from honest error. However, retraction notices often need to strike a balance between providing adequate information without being defamatory or libellous [2].

Over the past few years there have been reports that most cases of retraction are attributable to misconduct [3], with a notable rise in cases of fraud [4]. More recently there have been retractions from several journals across different publishers, including BioMed Central, due to systematic manipulation of the peer review processes by the provision of fabricated contact details for peer reviewers [5-8]. There have also been calls for journals to be more transparent regarding their retraction procedures and explicit in their retraction notices [9-12] especially as retraction notices have been found to vary between, and within, journals [13-15]. Given this, we analysed all retraction notices published at BioMed Central between January 2000 and December 2015 to determine how transparent notices were in terms of reason for retraction and information provided, and if they complied with the COPE guidelines. We also wanted to determine if retractions were on the increase.

Methods

All retraction notices published between January 2000 and December 2015 were identified using the publisher's publically available advanced search function [16] using the search term 'retraction' within the article title. Articles which had 'retraction' in the title, but were not themselves retractions were excluded. This time frame was selected because data were available across 15 complete years to date. Retractions were excluded if they were published by other publishers before the journal was transferred to BioMed Central.

Who issued the retraction notice and the reason for retraction were recorded. The time elapsed between publication of the original article and publication of the retraction notice was also recorded. Retractions were broadly classified according to the apparent underlying reason for the retraction into the following categories used in previous studies [3, 17]:

- honest error: defined as mistakes on the part of the author or publisher leading to publishing in error or unreliable data
- research misconduct: defined as data falsification/fabrication, failure to obtain ethical approval or consent, failure to obtain permission for data
- publishing misconduct: defined as plagiarism, duplicate publication, image duplication, authorship issues, compromised peer review.

Instances of data falsification or data fabrication were classified together as one category 'data falsification/fabrication'. Where it was not possible to distinguish 'honest error' from 'misconduct', the retraction notice was scored as 'unclear'. Where a retraction notice mentioned irregularities in the data and an institutional investigation the notice was scored as research misconduct unless honest error was explicitly mentioned.

All notices were classified by one author (EM) and checked for agreement by the other author (MK) using the information given in the retraction notice alone (i.e. no additional information was used). Where there was a difference in opinion, a discussion took place between the authors to reach a consensus. Where multiple reasons for the retraction were given the main reason was scored and the secondary reasons were noted. The scoring of the retraction notices is given in Supplementary File 1. Citations for all retracted articles were counted before and after the date of retraction by searching for the article or authors in Scopus [18] accessed on 26/2/2016. Citations to the retraction notice were also counted. Citation data are provided in Supplementary File 1.

Results

Between January 2000 and December 2015, our search identified 134 retraction notices. All retraction notices were clearly labelled and linked to the retracted article. Four retraction notices were not included because they were published by other publishers before the journal was transferred to BioMed Central.

The number of articles retracted each year has increased in recent times (Figure 1). The median time between publication of the article and its retraction was 337.5 days. Articles involving apparent misconduct took longer to retract (median of 386 days) than honest error (median of 184 days)

The largest proportion of retraction notices were issued by the authors (35%), followed by the Publisher and Editor(s) jointly (32%) and Editor alone (21%) as shown in Table 1.

Table 1. Number of retractions listed by who issued the retraction notice.

Who retracted?	Number of retractions
authors	47
authors and editor	1
Editor	28
journal	1
not stated	8
publisher	6
publisher and editor	43
Grand Total	**134**

No cases were recorded where the authors' institution issued a retraction. While the majority of retraction notices declared who was retracting the article, 6% of retraction notices did not explicitly state this information although it was implied that the notice was coming from the authors.

A detailed breakdown of the reasons for retraction is given in Table 2.

Table 2. Individual reasons for retraction.

Reason for retraction	Number of retractions
compromised peer review	44
plagiarism	22
data unreliable	14
data falsification/fabrication	10
published in error	10
duplicate publication	8
image duplication	6
unaware of manuscript submission	5
no ethical approval	5

no permission for data	5
undeclared conflict of interest	3
breach of editorial policy	1
no consent	1
Grand Total	**134**

The most common reason is compromises in peer review (33%), followed by plagiarism (16%) followed by problems with the data - i.e. the data was found to be 'unreliable' (10%). Other reasons include lack of appropriate ethical approvals or permission to use data (4% in each case), duplicate publication (6%), publication in error (7%), image manipulation (5%), or because of a lack of awareness by some authors of the manuscript's submission and publication (4%). 7% of retractions were due to data falsification/fabrication - reasons that were not seen in retraction notices before 2012. 2% of retractions were due to undeclared conflicts of interest either by the author (for example [19]) or by the reviewer (for example [20]). Not all retractions occurred for a single reason. In 13 cases of retraction there were two reasons (for example, [21, 22]] and in one case three reasons were given [23]. If the individual reasons for retraction are categorised into the underlying reasons of honest error, publishing misconduct or research misconduct (see Table 3) then most retractions originated due to some form of publishing misconduct as summarized in (Table 4).

Table 3. Classification of individual reasons for retraction into the main categories of honest error, publishing misconduct, research misconduct or unclear.

Reason for retraction	honest error	publishing misconduct	research misconduct	unclear
breach of editorial policy		1		
co-authors unaware		5		
compromised peer review		44		
data falsification/fabrication			10	
data unreliable	6			8
duplicate publication		7		1
image duplication	1	5		
no consent				1
no ethical approval			5	
no permission for data			3	2
plagiarism		22		
published in error	10			
undeclared conflict of interest				3

Table 4. Underlying reason for retraction.

Reason for retraction	Number of retractions
honest error	17
publishing misconduct	84
research misconduct	18
unclear	15
Grand Total	**134**

Figure 2 shows the growth and variation in reasons for retractions year-on-year. Plagiarism occurred as a reason for retraction from 2010 onwards. Retractions due to compromises in the peer review process were not seen before 2014.

Analysis of citations to articles before and after retraction in Scopus revealed that of 128 articles listed (for which data was available), articles were cited in the range 0-830 times before retraction and 0-30 times after retraction. The distribution of values is highly skewed, but the median number of citations is higher after retraction (3) than before retraction (1).

Discussion

General observations

Retraction rate did not increase faster than publication rate until 2015 (Supplementary file 2) when 43 articles were retracted due to compromised peer review.

Median number of days from publication to retraction was 337.5. Articles involving apparent misconduct took longer to retract (median of 386 days) than honest error (median of 184 days) as previously reported [24]. However, these times will all be overestimates of the *actual* time to retract because the issues leading to retraction are flagged after publication. For example, in one recent case, an article was retracted 11 years after publication in breach of editorial policy [25]. The actual time taken to retract was not itself 11 years, but shortly after the issue was raised.

Analysis of citations to articles before and after retraction revealed that articles continue to be cited after retraction as noted previously [26]. It's interesting that retracted articles continue to be cited much more than the retraction notices themselves which are rarely if ever cited (even though clearly linked to the original article). The fact that retraction notices are so seldom cited suggests that readers are unaware of the article's retraction.

Transparency of retraction notices

A reason for each retraction was always given and it was possible to classify retractions into discrete categories in most cases. However, in 11% of notices it was not possible to distinguish the underlying issue, honest error or misconduct, which ultimately led to retraction. This may have been due to legal constraints or limited information available from institutions for editors to make the distinction between honest error and misconduct. In other cases retraction notices were ambiguous. For example, the stated reason for one retraction [23] was 'published in error' although the notice alludes to other problems with the data which is likely to be the main reason for the retraction. Other articles were 'published in error' when a journal was transferred from another publisher and during this period an article was inadvertently published twice [27-29].

6% of notices did not state clearly who was retracting the article. In these notices, it was *implied*, but not explicitly stated, that the retraction was from the authors. These cases all occurred after the publication of the COPE guidelines on retraction which were not adhered to in this respect.

In 4% of cases, retractions occurred because not all authors had been aware of the manuscript submission. Retractions due to authorship disputes are not recommended by COPE [1] because if the scientific integrity of the article is not affected it should be possible to resolve the issue by other means (for example by publishing a correction). However, authorship disputes can sometimes be symptomatic of other more series underlying issues such as data theft. Retractions *solely* due to a lack of awareness or agreement on behalf of all authors has not occurred since 2009 it is possible that this is because straightforward authorship issues can be addressed by the publication of a correction and complicated disputes are eventually retracted for different reasons.

In order to further improve the transparency of retraction notices Publishers could use an internal checklist capturing the main information required in a retraction notice along with template wording as previously proposed [10,11].

Reasons for retraction

The majority of retractions were a result of publishing misconduct, as found in other larger studies (3, 13, 24). However, within this category, compromised peer review was the predominant reason (Table 2). Compromised peer review did not occur as a reason to retract at BioMed Central prior to

2014 (Figure 2). The majority of cases reported here date to a set of retractions in March 2015 related to compromised peer review [7].

Plagiarism was found to be the second main reason for retraction (Table 2) and has also been a predominant reason for retraction highlighted in other studies [3]. The rise in software to detect plagiarism (alongside development of sophisticated approaches to check figure manipulation [30]) has gone hand-in-hand with a rise in retractions due to plagiarism in recent years [13]. While the use of anti-plagiarism software before publication may prevent the occurrence of retractions due to plagiarism in future, we have seen cases where authors disguise the plagiarism, for example, by substituting different key words to evade detection. Often it is the order of identical references within a section of text, rather than the exact words used that reveals that plagiarism has occurred. Peer reviewers frequently detect "disguised plagiarism" more accurately than software programmes given their familiarity with previously published literature.

The third main reason for retraction was that the published data has subsequently been found to be unreliable in some way. 10% of retractions were due to problems with the data. Often these issues occurred through honest error in how the data were handled, for example [31, 32] although in some cases it is difficult to determine whether honest error or research misconduct was the cause. Recent initiatives towards increased transparency and reproducible research through encouraging sharing and deposition of data prior to publication [33-35] could have an impact on reducing instances of retraction due to errors with the data in future. In making data publication-ready many issues may be caught and fixed before publication.

Retractions due to research misconduct also occurred but these were in the minority. In some cases notices were transparent (for example [36]), in other cases less so. Several retractions were due to lack of appropriate ethical approvals (4%) or permission to use data (4%). It is difficult to pinpoint measures that Editors or reviewers can take to detect fraudulent and unethical practices *before* publication or even prevent them happening at all [37]. However, having policies in place to encourage explicit author contributions, declaration of conflicts of interests (for authors and reviewers), data sharing, adherence to reporting guidelines and ensuring the correct ethical approvals and permissions to publish data were obtained are vital. Most recently, the *BMJ* introduced a 'transparency declaration', requiring the lead author to confirm that the manuscript is an honest, accurate, and transparent account of the study being reported [38]. It will be interesting to see if this has any effect on reducing retractions in future. While the decision to act unethically rests with the researcher [39], the tremendous pressures that continue to be placed on researchers to 'publish or perish' [40, 41] may unintentionally fuel acts of misconduct [8, 42]. Clearly, there is a

real need for integrity and transparency at all levels [39], from those in research (researchers and their institutions) to those making editorial recommendations (peer reviewers and Editors).

Conclusions

We found that COPE guidelines on retraction were adhered to in that an explicit reason for retraction was given in all cases of retraction evaluated from 2000-2015. However, in some cases notices did not document who issued the notice and there were ambiguities as to the underlying cause (honest error or misconduct). In future, adopting a checklist (linking to COPE guidelines) and a standard template for various classes of retraction notices would facilitate increased transparency and consistency of retraction notices. There may also be a need for making the retraction notice more obvious on the original article given that the retracted articles are always more highly cited than the retraction notice, post retraction.

In general, across the publishing industry, Editors are adopting procedures and policies which may help to reduce certain classes of retraction. For example, many journals including many BioMed Central journals now screen for plagiarism and encourage data sharing and data deposition prior to publication. However, robust publication ethics does not fall solely to Editors. Publication ethics is inclusive – authors, peer reviewers, Editors, Publishers and institutions all have their part to play to foster a culture of trust and transparency and maintain the integrity of the published literature.

Authors' contributions

ECM and MKK designed the study, collated and classified the data. MKK analysed the data. Both authors contributed to the writing of the manuscript and its revision. Both authors approved the final version. Both authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Competing interests

Both authors have completed the ICMJE uniform disclosure form and declare we are employed by BioMed Central. Since the manuscript has been revised ECM has been co-opted as a COPE Council Member, but this study did not involve COPE. We declare no other relationships or activities that could appear to have influenced the submitted work.

Data sharing

The full data set of the scoring of the retraction notices is provided in the accompanying additional file (Supplementary File 1) and can be accessed there.

Transparency

The lead author (the manuscript's guarantor) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Figures

Figure 1. Growth in retractions compared to growth in total articles published.

Figure 2. Growth in retractions and variation in reasons for retracting articles from 2000 – 2015. Plagiarism occurred as a reason for retraction from 2010 onwards when use of plagiarism detection software became more widespread.

Supplementary files

Supplementary file 1. Data set of retractions.

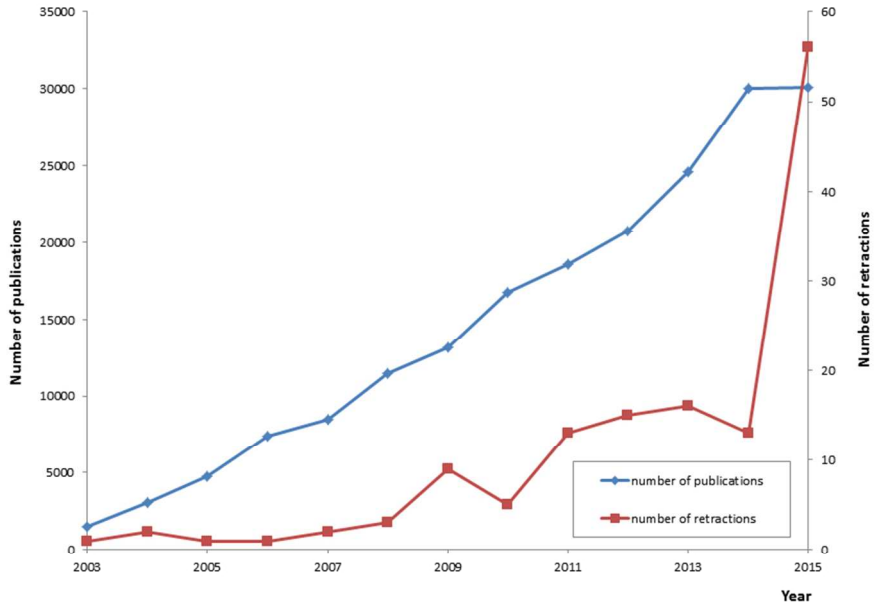

Figure 1. Growth in retractions compared to growth in total articles published.

254x190mm (96 x 96 DPI)

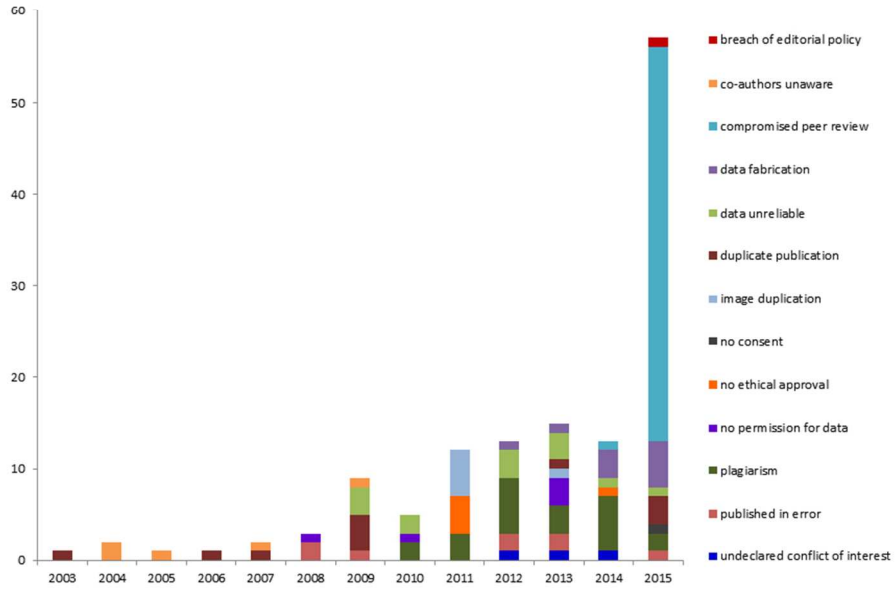

Figure 2. Growth in retractions and variation in reasons for retracting articles from 2000 – 2015. Plagiarism occurred as a reason for retraction from 2010 onwards when use of plagiarism detection software became more widespread.

254x190mm (96 x 96 DPI)

link to retraction notice	Citations before retraction (in Scopus)	Citations after retraction (in Scopus)	retraction cited?	Journal	date article published	date retraction posted	# days between publication and retraction	Reason for retraction	Who retracted	year retraction posted
http://www.arthritis-research.com/content/17/1/354	49	2	0	*Arthritis Research &Therapy*	20/09/2011	09/12/2015	1541	data fabrication	authors	2015
http://www.scoliosisjournal.com/content/10/1/34	0	1	0	*Scoliosis*	12/06/2015	03/12/2015	174	published in error	authors and editor	2015
http://www.jneuroinflammation.com/content/12/1/220	7	3	0	*Journal of Neuroinflammation*	22/01/2014	26/11/2015	673	data fabrication	Editor	2015
http://bmcophthalmol.biomedcentral.com/articles/10.1186/s12886-015-0114-z	3	2	0	*BMC Opthalmology*	09/04/2013	16/11/2015	951	duplicate publication	Editor	2015
http://bmcevolbiol.biomedcentral.com/articles/10.1186/s12862-015-0513-z	830	12	0	*BMC Evolutionary Biology*	28/06/2004	05/11/2015	4147	breach of editorial policy	Editor	2015
http://bmcgenomics.biomedcentral.com/articles/10.1186/s12864-015-1802-z	2	1	0	*BMC Genomics*	11/12/2014	03/08/2015	235	data unreliable	authors	2015
http://particleandfibretoxicology.biomedcentral.com/articles/10.1186/s12989-015-0097-1	23	6	0	*Particle and Fibre Toxicology*	13/02/2013	14/07/2015	881	data fabrication	Editor	2015
http://particleandfibretoxicology.biomedcentral.com/articles/10.1186/s12989-015-0098-0	1	4	0	*Particle and Fibre Toxicology*	12/09/2014	14/07/2015	305	data fabrication	Editor	2015
http://diagnosticpathology.biomedcentral.com/articles/10.1186/s13000-015-0240-1	0	1	1	*Diagnostic Pathology*	01/07/2014	26/03/2015	268	compromised peer review	Publisher & Editor	2015
http://cancerci.biomedcentral.com/articles/10.1186/s12935-015-0199-8	0	1	0	*Cancer Cell International*	19/12/2014	24/06/2015	187	compromised peer review	Publisher & Editor	2015
http://bmcmusculoskeletdisord.biomedcentral.com/articles/10.1186/s12891-015-0462-0	4	1	0	*BMC Musculoskeletal Disorders*	17/11/2009	19/06/2015	2040	plagiarism	Editor	2015
http://diagnosticpathology.biomedcentral.com/articles/10.1186/s13000-015-0237-9	0	1	0	*Diagnostic Pathology*	26/09/2014	13/05/2015	229	compromised peer review	Publisher & Editor	2015
http://aacijournal.biomedcentral.com/articles/10.1186/s13223-015-0079-8	not in scopus	?	?	*Allergy, Asthma & Clinical Immunology*	18/12/2014	17/04/2015	120	duplicate publication	authors	2015
http://jehse.biomedcentral.com/articles/10.1186/s40201-015-0182-2	0	1	0	*Journal of Environmental Health Science and Engineering*	27/12/2014	17/04/2015	111	duplicate publication	Editor	2015

http://rbej.biomedcentral.com/articles/10.1186/s12958-015-0016-1	13	1	0	*Reproductive Biology and Endocrinology*	16/12/2003	03/04/2015	4126	data fabrication	Editor	2015
http://www.eurjmedres.com/content/20/1/44	15	1	0	*European Journal of Medical Research*	30/07/2013	31/03/2015	609	compromised peer review	Publisher & Editor	2015
http://www.cardiothoracicsurgery.org/content/10/1/42	0	1	0	*Journal of Cardiothoracic Surgery*	05/12/2014	27/03/2015	112	compromised peer review	Publisher & Editor	2015
http://www.cardiothoracicsurgery.org/content/10/1/43	6	2	0	*Journal of Cardiothoracic Surgery*	28/02/2014	27/03/2015	392	compromised peer review	Publisher & Editor	2015
http://diagnosticpathology.biomedcentral.com/articles/10.1186/s13000-015-0239-7	0	1	0	*Diagnostic Pathology*	17/06/2013	26/03/2015	647	compromised peer review	Publisher & Editor	2015
http://ovarianresearch.biomedcentral.com/articles/10.1186/s13048-015-0147-1	1	1	0	*Journal of Ovarian Research*	17/12/2013	26/03/2015	464	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/33	1	1	0	*European Journal of Medical Research*	21/03/2014	26/03/2015	370	compromised peer review	Publisher & Editor	2015
http://ovarianresearch.biomedcentral.com/articles/10.1186/s13048-015-0145-3	1	2	0	*Journal of Ovarian Research*	21/01/2014	26/03/2015	429	compromised peer review	Publisher & Editor	2015
http://bmcmusculoskeletdisord.biomedcentral.com/articles/10.1186/s12891-015-0528-z	2	1	0	*BMC Musculoskeletal Disorders*	22/05/2014	26/03/2015	308	compromised peer review	Publisher & Editor	2015
http://www.jmedicalcasereports.com/content/9/1/70	0	1	0	*Journal of Medical Case Reports*	26/03/2014	26/03/2015	365	no consent	Editor	2015
http://bmcgastroenterol.biomedcentral.com/articles/10.1186/s12876-015-0265-7	0	1	0	*BMC Gastroenterology*	03/04/2014	26/03/2015	357	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/40	0	1	0	*European Journal of Medical Research*	14/12/2013	26/03/2015	467	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/34	0	1	0	*European Journal of Medical Research*	10/12/2013	26/03/2015	471	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/39	4	6	0	*European Journal of Medical Research*	06/12/2013	26/03/2015	475	compromised peer review	Publisher & Editor	2015

http://www.eurjmedres.com/content/20/1/37	0	1	0	*European Journal of Medical Research*	29/10/2014	26/03/2015	148	compromised peer review	Publisher & Editor	2015
http://diagnosticpathology.biomedcentral.com/articles/10.1186/s13000-015-0238-8	14	7	0	*Diagnostic Pathology*	21/10/2013	26/03/2015	521	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/43	0	1	0	*European Journal of Medical Research*	01/09/2013	26/03/2015	571	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/32	1	1	0	*European Journal of Medical Research*	27/12/2013	26/03/2015	454	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/36	1	1	0	*European Journal of Medical Research*	29/05/2014	26/03/2015	301	compromised peer review	Publisher & Editor	2015
http://wjso.biomedcentral.com/articles/10.1186/s12957-015-0547-0	4	4	0	*World Journal of Surgical Oncology*	10/12/2013	26/03/2015	471	compromised peer review	Publisher & Editor	2015
http://diagnosticpathology.biomedcentral.com/articles/10.1186/s13000-015-0241-0	1	1	0	*Diagnostic Pathology*	26/09/2014	26/03/2015	181	compromised peer review	Publisher & Editor	2015
http://ovarianresearch.biomedcentral.com/articles/10.1186/s13048-015-0144-4	0	3	0	*Journal of Ovarian Research*	30/09/2014	26/03/2015	177	compromised peer review	Publisher & Editor	2015
http://bmccancer.biomedcentral.com/articles/10.1186/s12885-015-1162-8	3	3	0	*BMC Cancer*	16/01/2014	26/03/2015	434	compromised peer review	Publisher & Editor	2015
http://bmccardiovascdisord.biomedcentral.com/articles/10.1186/s12872-015-0019-z	2	2	0	*BMC Cardiovascular Disorders*	17/04/2014	26/03/2015	343	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0183-y	3	1	0	*Journal of Orthopaedic Surgery and Research*	11/04/2014	26/03/2015	349	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0180-1	1	1	0	*Journal of Orthopaedic Surgery and Research*	16/08/2014	26/03/2015	222	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0179-7	0	1	0	*Journal of Orthopaedic Surgery and Research*	10/03/2014	26/03/2015	381	compromised peer review	Publisher & Editor	2015

http://bmcneurol.biomedcentral.com/articles/10.1186/s12883-015-0307-3	3	1	0	*BMC Neurology*	20/11/2013	26/03/2015	491	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/38	3	2	0	*European Journal of Medical Research*	20/12/2013	26/03/2015	461	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/30	2	1	0	*European Journal of Medical Research*	04/10/2013	26/03/2015	538	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/35	6	2	0	*European Journal of Medical Research*	17/12/2013	26/03/2015	464	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/42	2	5	0	*European Journal of Medical Research*	23/04/2014	26/03/2015	337	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/31	2	1	0	*European Journal of Medical Research*	14/11/2013	26/03/2015	497	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/41	0	3	0	*European Journal of Medical Research*	20/08/2014	26/03/2015	218	compromised peer review	Publisher & Editor	2015
http://diagnosticpathology.biomedcentral.com/articles/10.1186/s13000-015-0236-x	3	1	0	*Diagnostic Pathology*	23/08/2013	26/03/2015	580	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0176-x	1	2	0	*Journal of Orthopaedic Surgery and Research*	15/04/2014	26/03/2015	345	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0182-z	0	1	0	*Journal of Orthopaedic Surgery and Research*	12/12/2014	26/03/2015	104	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0178-8	1	1	0	*Journal of Orthopaedic Surgery and Research*	23/04/2014	26/03/2015	337	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0181-0	0	1	0	*Journal of Orthopaedic Surgery and Research*	17/03/2014	26/03/2015	374	compromised peer review	Publisher & Editor	2015

http://www.eurjmedres.com/content/20/1/29	1	1	0	*European Journal of Medical Research*	16/09/2014	26/03/2015	191	compromised peer review	Publisher & Editor	2015
http://ovarianresearch.biomedcentral.com/articles/10.1186/s13048-015-0146-2	3	6	1	*Journal of Ovarian Research*	06/12/2013	26/03/2015	475	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0177-9	0	0	0	*Journal of Orthopaedic Surgery and Research*	21/02/2014	26/03/2015	398	compromised peer review	Publisher & Editor	2015
http://bmcsurg.biomedcentral.com/articles/10.1186/1471-2482-15-2	14	2	0	*BMC Surgery*	08/10/2013	14/01/2015	463	plagiarism	authors	2015
http://www.biomedcentral.com/1756-0500/7/868	0	3	0	*BMC Research Notes*	21/01/2014	25/11/2014	308	no ethical approval	editor	2014
http://www.annals-general-psychiatry.com/content/13/1/30	0	1	0	*Annals of General Psychiatry*	12/04/2014	26/11/2014	228	plagiarism	authors	2014
http://www.translationalneurodegeneration.com/content/3/1/22	1	2	0	*Translational Neurodegeneration*	27/08/2014	03/10/2014	37	undeclared conflict of interest	Editor	2014
http://www.nutritionandmetabolism.com/content/11/1/43	0	2	0	*Nutrition & Metabolism*	06/06/2014	24/09/2014	110	plagiarism	editor	2014
http://www.biomedcentral.com/1752-0509/8/105	13	8	0	*BMC Systems Biology*	21/03/2012	18/09/2014	911	compromised peer review	editor	2014
http://www.biomedcentral.com/1471-2393/14/202	1	4	2	*BMC Pregnancy and Childbirth*	12/08/2013	03/07/2014	325	data unreliable	authors	2014
http://www.dmsjournal.com/content/6/1/60	2	7	0	*Diabetology & Metabolic Syndrome*	02/09/2013	27/05/2014	267	plagiarism	editor	2014
http://www.dmsjournal.com/content/6/1/59	2	3	0	*Diabetology & Metabolic Syndrome*	01/05/2013	27/05/2014	391	plagiarism	editor	2014
http://www.molecularpain.com/content/10/1/20	8	2	0	*Molecular Pain*	11/01/2012	02/04/2014	812	data fabrication	authors	2014
http://www.ijponline.net/content/40/1/9	7	5	0	*Italian Journal of Pediatrics*	23/07/2012	11/03/2014	596	plagiarism	authors	2014
http://www.nutritionandmetabolism.com/content/11/1/11	32	14	1	*Nutrition & Metabolism*	18/10/2008	14/02/2014	1945	plagiarism	editor	2014
http://www.retrovirology.com/content/11/1/16	not in scopus	?	0	*Retrovirology*	13/09/2012	06/02/2014	511	data fabrication	authors	2014
http://www.biomedcentral.com/1472-6793/13/13	17	3	0	*BMC Physiology*	12/05/2010	10/01/2014	1339	data fabrication	authors	2014
http://www.biomedical-engineering-online.com/content/12/1/113	7	2	0	*BioMedical Engineering OnLine*	05/05/2004	06/12/2013	3502	image duplication	publisher	2013

http://www.cancerci.com/content/13/1/96	2	4	0	*Cancer Cell International*	29/05/2012	22/10/2013	511	data unreliable	authors	2013
http://www.biomedcentral.com/1756-0500/6/422	1	5	0	*BMC Research Notes*	23/02/2012	18/10/2013	603	no permission for data	editor	2013
http://www.biomedcentral.com/1756-0500/6/332	0	1	0	*BMC Research Notes*	06/05/2013	20/08/2013	106	data unreliable	authors	2013
http://www.diagnosticpathology.org/content/8/1/127	2	13	0	*Diagnostic Pathology*	07/12/2012	14/08/2013	250	plagiarism	authors	2013
http://www.aacijournal.com/content/9/1/28	not in scopus	?	1	*Allergy, Asthma & Clinical Immunology*	15/07/2013	12/08/2013	28	no permission for data	authors	2013
http://www.biomedcentral.com/1472-6750/13/57	4	5	1	*BMC Biotechnology*	06/01/2011	20/07/2013	926	data fabrication	authors	2013
http://www.skeletalmusclejournal.com/content/3/1/15	?	?	0	*Skeletal Muscle*	27/04/2012	18/07/2013	447	data unreliable	authors	2013
http://www.translational-medicine.com/content/11/1/144	0	8	0	*Journal of Translational Medicine*	05/12/2012	11/06/2013	188	published in error	publisher	2013
http://www.biomedcentral.com/1472-6963/13/180	0	1	0	*BMC Health Services Research*	21/12/2012	20/05/2013	150	no permission for data	authors	2013
http://www.jdmdonline.com/content/12/1/21	0	2	0	*Journal of Diabetes & Metabolic Disorders*	22/12/2012	14/05/2013	143	published in error	publisher	2013
http://www.scoliosisjournal.com/content/8/1/7	0	2	0	*Scoliosis*	28/05/2012	03/05/2013	340	undeclared conflict of interest	editor	2013
http://www.proteomesci.com/content/11/1/16	5	3	0	*Proteome Science*	02/06/2011	23/04/2013	691	plagiarism	editor	2013
http://www.jdmdonline.com/content/11/1/21	0	2	6	*Journal of Diabetes & Metabolic Disorders*	24/08/2012	07/03/2013	195	duplicate publication	not stated	2013
http://www.jasbsci.com/content/4/1/3	0	21	0	*Journal of Animal Science and Biotechnology*	22/08/2012	23/01/2013	154	plagiarism	authors	2013
http://www.biomedcentral.com/1472-6882/12/206	1	22	0	*BMC Complementary and Alternative Medicine*	20/09/2011	02/11/2012	409	plagiarism	journal	2012
http://breast-cancer-research misconduct.com/content/14/5/402	0	9	1	*Breast Cancer Research*	06/03/2012	31/10/2012	239	data unreliable	authors	2012
http://www.gvt-journal.com/content/10/1/10	0	0	1	*Genetic Vaccines and Therapy*	20/06/2012	23/10/2012	125	undeclared conflict of interest	editor	2012

http://www.jnanobiotechnology.com/content/10/1/40	0	22	0	*Journal of Nanobiotechnology*	20/07/2012	04/10/2012	76	plagiarism	not stated	2012
http://www.wjso.com/content/10/1/196	6	17	2	*World Journal of Surgical Oncology*	30/04/2010	20/09/2012	874	plagiarism	authors	2012
http://www.molecular-cancer.com/content/11/1/57	56	30	1	*Molecular Cancer*	23/03/2006	20/08/2012	2342	plagiarism	authors	2012
http://www.biomedcentral.com/1471-2121/13/17	0	1	0	*BMC Cell Biology*	26/03/2012	26/06/2012	92	plagiarism	editor	2012
http://www.biomedcentral.com/1756-0500/5/319	0	5	0	*BMC Research Notes*	20/12/2011	21/06/2012	184	published in error	editor	2012
http://www.celldiv.com/content/7/1/15	5	13	0	*Cell Division*	21/01/2010	15/05/2012	845	plagiarism	not stated	2012
http://www.ctajournal.com/content/2/1/6	not in scopus	?	?	*Clinical and Translational Allergy*	25/08/2011	16/03/2012	204	data unreliable	authors	2012
http://www.jeccr.com/content/31/1/21	0	3	0	*Journal of Experimental & Clinical Cancer Research*	10/11/2011	13/03/2012	124	data unreliable	authors	2012
http://www.cardiothoracicsurgery.org/content/7/1/17	1	4	0	*Journal of Cardiothoracic Surgery*	12/05/2011	06/03/2012	299	published in error	editor	2012
http://www.biomedcentral.com/1471-2172/13/3	0	0	0	*BMC Immunology*	11/11/2011	16/01/2012	66	data fabrication	authors	2012
http://www.retrovirology.com/content/8/1/88	0	4	2	*Retrovirology*	06/01/2011	05/11/2011	303	image duplication	authors	2011
http://www.wjso.com/content/9/1/136	0	2	1	*World Journal of Surgical Oncology*	13/07/2011	24/10/2011	103	plagiarism	authors	2011
http://www.chiromt.com/content/19/1/24	2	1	0	*Chiropractic & Manual Therapies*	09/08/2010	03/10/2011	420	no ethical approval	not stated	2011
http://www.biomedcentral.com/1746-6148/7/56	0	9	1	*BMC Veterinary Research*	29/04/2011	20/09/2011	144	plagiarism	authors	2011
http://www.biomedcentral.com/1471-2474/12/200	3	6	0	*BMC Musculoskeletal Disorders*	08/04/2010	13/09/2011	523	no ethical approval	not stated	2011
http://www.biomedcentral.com/1471-2474/12/158	4	13	0	*BMC Musculoskeletal Disorders*	17/04/2009	13/07/2011	817	no ethical approval	not stated	2011
http://www.biomedcentral.com/1471-2474/12/159	0	5	0	*BMC Musculoskeletal Disorders*	19/10/2010	13/07/2011	267	no ethical approval	not stated	2011
http://www.biomedcentral.com/1471-2164/12/284	6	25	0	*BMC Genomics*	28/09/2009	02/06/2011	612	image duplication	authors	2011

http://www.biomedcentral.com/1471-2180/11/128	7	13	1	*BMC Microbiology*	12/02/2009	02/06/2011	840	image duplication	editor	2011
http://www.biomedcentral.com/1471-2180/11/127	0	3	0	*BMC Microbiology*	05/01/2010	02/06/2011	513	image duplication	editor	2011
http://www.jeccr.com/content/30/1/19	1	10	1	*Journal of Experimental & Clinical Cancer Research*	11/10/2010	16/02/2011	128	plagiarism	authors	2011
http://www.retrovirology.com/content/8/1/1	19	10	0	*Retrovirology*	09/04/2006	06/01/2011	1733	image duplication	authors	2011
http://www.biomedcentral.com/1472-6939/11/20	0	3	0	*BMC Medical Ethics*	15/09/2010	21/12/2010	97	plagiarism	authors	2010
http://www.parasitesandvectors.com/content/3/1/78	0	2	0	*Parasites & Vectors*	24/06/2010	25/08/2010	62	data unreliable	editor	2010
http://www.virologyj.com/content/7/1/190	0	1	0	*Virology Journal*	21/07/2010	13/08/2010	23	data unreliable	editor	2010
http://www.biomedcentral.com/1471-2105/11/258	0	1	0	*BMC Bioinformatics*	18/01/2010	18/05/2010	120	plagiarism	not stated	2010
http://www.cmjournal.org/content/5/1/10	0	2	0	*Chinese Medicine*	27/11/2009	16/03/2010	109	no permission for data	authors	2010
www.jmedicalcasereports.com/content/3/1/122	0	4	0	*Journal of Medical Case Reports*	31/07/2008	13/11/2009	470	published in error	publisher	2009
http://www.molecularneurodegeneration.com/content/4/1/45	2	6	0	*Molecular Neurodegeneration*	01/10/2007	04/11/2009	765	data unreliable	authors	2009
http://www.biomedcentral.com/1472-6947/9/45	0	3	0	*BMC Medical Informatics and Decision Making*	09/11/2007	20/10/2009	711	data unreliable	editor	2009
www.microbialcellfactories.com/content/8/1/52	not in scopus	?	?	*Microbial Cell Factories*	20/07/2009	15/10/2009	87	duplicate publication	authors	2009
http://www.molecular-cancer.com/content/8/1/84	0	5	0	*Molecular Cancer*	27/09/2009	14/10/2009	17	duplicate publication	authors	2009
http://www.jeccr.com/content/28/1/137	1	8	0	*Journal of Experimental & Clinical Cancer Research*	16/07/2009	09/10/2009	85	duplicate publication	authors	2009
http://www.jeccr.com/content/28/1/101	2	14	0	*Journal of Experimental & Clinical Cancer Research*	12/08/2008	16/07/2009	338	duplicate publication	authors	2009
http://www.issoonline.com/content/6/1/11	0	3	0	*International Seminars in Surgical Oncology*	05/02/2009	17/04/2009	71	co-authors unaware	authors	2009

http://www.hqlo.com/content/7/1/34	0	4	1	*Health and Quality of Life Outcomes*	30/01/2009	17/04/2009	77	data unreliable	authors	2009
http://www.biomedcentral.com/1471-2342/8/15	0	4	2	*BMC Medical Imaging*	31/01/2007	11/08/2008	558	no permission for data	authors	2008
http://www.jautoimdis.com/content/5/1/5	0	12	0	*Journal of Autoimmune Diseases*	29/07/2008	11/08/2008	13	published in error	publisher	2008
http://www.carcinogenesis.com/article.asp?issn=1477-3163;year=2008;volume=7;issue=1;spage=4;epage=4;aulast=Weiner	0	4	0	*Journal of Carcinogenesis*	28/07/2008	08/08/2008	11	published in error	publisher	2008
http://www.virologyj.com/content/4/1/119	0	6	0	*Virology Journal*	24/09/2007	31/10/2007	37	co-authors unaware	authors	2007
http://www.josr-online.com/content/2/1/6	0	4	1	*Journal of Orthopaedic Surgery and Research*	02/11/2006	04/04/2007	153	duplicate publication	authors	2007
http://www.cardiovascularultrasound.com/content/4/1/42	0	6	0	*Cardiovascular Ultrasound*	16/10/2006	08/11/2006	23	duplicate publication	authors	2006
http://www.molecular-cancer.com/content/4/1/17	0	3	2	*Molecular Cancer*	05/04/2005	06/05/2005	31	co-authors unaware	authors	2005
http://www.molecular-cancer.com/content/3/1/1	0	10	0	*Molecular Cancer*	23/09/2003	14/01/2004	113	co-authors unaware	authors	2004
http://www.molecular-cancer.com/content/3/1/2	0	6	0	*Molecular Cancer*	07/08/2003	14/01/2004	160	co-authors unaware	authors	2004
http://www.molecular-cancer.com/content/2/1/17	0	10	0	*Molecular Cancer*	03/01/2003	03/03/2003	59	duplicate publication	authors	2003

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Why articles are retracted: a retrospective cross-sectional study of retraction notices at BioMed Central

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Why articles are retracted: a retrospective cross-sectional study of retraction notices at BioMed Central

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Abstract

Objectives

To assess why articles are retracted from BioMed Central journals, whether retraction notices adhered to the Committee on Publication Ethics (COPE) guidelines, and are becoming more frequent as a proportion of published articles.

Design/setting

Retrospective cross-sectional analysis of 134 retractions from January 2000 – December 2015.

Results

134 retraction notices were published during this timeframe. Although they account for 0.07% of all articles published (190514 excluding supplements, corrections, retractions and commissioned content), the rate of retraction is rising. COPE guidelines on retraction were adhered to in that an explicit reason for each retraction was given. However, some notices did not document who retracted the article (8 articles, 6%) and others were unclear whether the underlying cause was honest error or misconduct (15 articles, 11%). The largest proportion of notices were issued by the authors (47 articles, 35%). The majority of retractions were due to some form of misconduct (102 articles, 76%) i.e. compromised peer review (44 articles, 33%), plagiarism (22 articles, 16%) and data falsification/fabrication (10 articles, 7%). Honest error accounted for 17 retractions (13%) of which 10 articles (7%) were published in error. The median number of days from publication to retraction was 337.5 days.

Conclusions

The most common reason to retract was compromised peer review. However, the majority of these cases date to March 2015 and appear to be the result of a systematic attempt to manipulate peer review across several publishers. Retractions due to plagiarism account for the second largest category and may be reduced by screening manuscripts *before* publication although this is not guaranteed. Retractions due to problems with the data may be reduced by appropriate data sharing and deposition before publication. Adopting a checklist (linked to COPE guidelines) and templates for various classes of retraction notices would increase transparency of retraction notices in future.

Strengths and limitations of this study

- The first study to examine all BioMed Central retraction notices published in 2000-2015 and the retraction patterns of a single publisher.
- The first study to examine transparency of retraction notices and adherence to COPE retraction guidelines by a single publisher.
- The study is limited by the number of retractions published to analyse and any correlations with a particular journal, article type, discipline or peer review model have not been explored.

Introduction

Retractions are a permanent means of maintaining the integrity of the scientific literature and necessary to alert the reader to serious problems identified with a published article. The Committee on Publication Ethics (COPE) published retraction guidelines in 2009 [1]. These guidelines advise on retracting articles if the main findings are found to be unreliable (either as a result of misconduct or honest error), redundant (i.e. previously published elsewhere in a citable format), plagiarised (text or figures) or if the authors have reported unethical research or failed to disclose a major competing interest which could influence the interpretation of the article.

COPE recommends that retraction notices provide adequate information so that readers know *who* is retracting the article and *why* the findings are considered unreliable, while clearly distinguishing forms of misconduct from honest error. However, retraction notices often need to strike a balance between providing adequate information without being defamatory or libellous [2]. In addition, retractions should be clearly identifiable; freely available; published promptly and be linked to the original article that is retracted (which should also be identified as a retraction.)

Over the past few years there have been reports that most cases of retraction are attributable to misconduct [3], with a notable rise in cases of fraud (data fabrication or falsification) [4]. More recently there have been retractions from several journals across different publishers, including BioMed Central, due to systematic manipulation of the peer review processes by the provision of fabricated contact details for peer reviewers [5-8]. There have also been calls for journals to be more transparent regarding their retraction procedures and explicit in their retraction notices [9-12] especially as retraction notices have been found to vary between, and within, journals [13-15]. Given this, we analysed all retraction notices published at BioMed Central between January 2000 and December 2015 to determine how transparent notices were in terms of reason for retraction and

information provided, and if they complied with the COPE guidelines. We also wanted to determine if retractions were on the increase.

Methods

All retraction notices published between January 2000 and December 2015 were identified using the publisher's publically available advanced search function [16] using the search term 'retraction' within the article title. This time frame was selected because it spanned the largest window of retractions available to record - from the first retractions BioMed Central had ever published through to 2015, i.e. 15 complete years to date. Articles which had 'retraction' in the title, but were not themselves retractions were excluded. Retractions were excluded if they were published by other publishers before the journal was transferred to BioMed Central.

Who issued the retraction notice and the reason for retraction were recorded. The time elapsed between publication of the original article and publication of the retraction notice was also recorded. After considering classifications of retractions in previous studies [3, 17] retractions were broadly classified according to the apparent underlying reason for the retraction into the following broad categories:

- **honest error**: defined as mistakes on the part of the author or publisher leading to publishing in error or unreliable data
- **misconduct**: defined as data falsification/fabrication, failure to obtain ethical approval or consent, failure to obtain permission for data, plagiarism, duplicate publication, image duplication, authorship issues, compromised peer review.
- **unclear**: where it was not possible to distinguish 'honest error' from 'misconduct'

Instances of data falsification or data fabrication were classified together as one category 'data falsification/fabrication'. Where a retraction notice mentioned irregularities in the data and an institutional investigation, the notice was described as misconduct unless honest error was explicitly mentioned.

All notices were classified by one author (ECM) and checked for agreement by the other author (MKK) using the information given in the retraction notice alone (i.e. no additional information was used). Where there was a difference in opinion, a discussion took place between the authors to reach a consensus. Where multiple reasons for the retraction were given the main reason was described and the secondary reasons were noted. The descriptions of the retraction notices are

given in Supplementary File 1 (Raw data for BMJ Open 2016) and the explanations (for the purposes of this study) are as follows:

- plagiarism: duplication of text from previously published articles
- compromised peer review: compromises in the independent assessment of the manuscript by a peer
- data unreliable: data has errors in data
- data falsification/fabrication: data has been manipulated or made up
- published in error: article was accidently published twice as a result of publisher error
- duplicate publication: article was published twice (usually as a result of author misconduct)
- image duplication: duplication of images from previously published articles
- authors unaware of manuscript submission: not all authors aware
- no ethical approval: the study had no ethical approval
- no consent: the study involved people who had not given consent
- no permission for data: authors did not have permission to use the data reported
- undeclared conflict of interest: authors or reviewers did not declare a conflict of interest
- breach of editorial policy: the manuscript breached an editorial policy

Citations for all retracted articles were counted before and after the date of retraction by searching for the article or authors in Scopus [18] accessed on 26/2/2016. Citations to the retraction notice were also counted. Citation data are provided in Supplementary File 1. For further clarity a checklist of the STROBE recommendations [19] for the reporting of observational studies has been completed and is provided in Supplementary File 2.

Results

Between January 2000 and December 2015, our search identified 134 retraction notices. This accounts for 0.07% of all articles published (a total of 190514 articles excluding supplements, corrections, retractions and commissioned content).

All retraction notices were clearly labelled and linked to the retracted article except for cases where for legal reasons the original article could no longer be made available (for example, if there was sensitive information or if plagiarism infringed another journal's copyright). Four retraction notices were not included because they were published by other publishers before the journal was transferred to BioMed Central.

Figure 1 shows the growth in retractions compared to growth in total articles published (excluding supplements, corrections, retractions and commissioned content). Proportionally there was no increase in retraction rate until 2015 when the retraction rate increased due to 43 articles that were retracted due to compromises in peer review (Supplementary file 1). The median time between publication of the article and its retraction was 337.5 days (with a minimum of 11 days and a maximum of 4147 days). Articles involving apparent misconduct took longer to retract (median of 386 days; minimum 17 days, maximum 4147 days) than honest error (median of 184 days; minimum 11 days, maximum 3361 days).The largest proportion of retraction notices were issued by the authors (47 articles, 35%), followed by the publisher and editor(s) jointly (43 articles, 32%) and editor alone (28 articles, 21%) as shown in Table 1.

Table 1. Number of retractions listed by who issued the retraction notice.

Who retracted?	Number of retractions
authors	47
authors and editor	1
editor	28
journal	1
publisher	6
publisher and editor	43
information not provided	8
Grand Total	**134**

No cases were recorded where the authors' institution issued a retraction. While the majority of retraction notices declared who was retracting the article, 8 retraction notices (6%) did not explicitly state this information.

A detailed breakdown of the reasons for retraction is given in Table 2.

The most common reason for retraction is compromises in peer review (44 articles, 33%), followed by plagiarism (22 articles, 16%) followed by problems with the data - i.e. the data was found to be 'unreliable' (13 articles, 10%). Other reasons include lack of appropriate ethical approvals (5 articles, 4%) or permission to use data 5 articles, 4%), duplicate publication (11 articles, 8%), published in error (8 articles, 6%) where an article was accidently published twice [20-22], image duplication (6 articles, 4%), or because of a lack of awareness by some authors of the manuscript's submission and publication (5 articles, 4%). 10 retractions (7%) were due to data falsification/fabrication - reasons that were not seen in retraction notices before 2012. Three articles (2%) were retracted due to undeclared conflicts of interest either by the author (for example [23]) or by the reviewer (for

example [24]). Not all retractions occurred for a single reason. In 13 cases of retraction there were two reasons (for example, [25, 26]] and in one case three reasons were given [27]. If the individual reasons for retraction are categorised into the underlying reasons of honest error, misconduct or unclear (see Table 2) then most retractions originated due to some form of misconduct.

Table 2. Individual reasons for retraction and classification into the main categories of honest error, misconduct or unclear.

Reason for retraction	honest error	misconduct	unclear
breach of editorial policy		1	
co-authors unaware of manuscript submission		5	
compromised peer review		44	
data falsification/fabrication		10	
data unreliable	6		8
duplicate publication		7	1
image duplication	1	5	
no consent			1
no ethical approval		5	
no permission for data		3	2
plagiarism		22	
published in error	10		
undeclared conflict of interest			3
Sub-totals per broad category	17	102	15

Figure 2 shows the growth and variation in reasons for retractions year-on-year. Plagiarism occurred as a reason for retraction from 2010 onwards. Retractions due to compromises in the peer review process were not seen before 2014.

Analysis of citations to articles before and after retraction in Scopus revealed that of 128 articles listed (for which data was available), articles were cited in the range 0-830 times before retraction and 0-30 times after retraction. The distribution of values is highly skewed, but the median number of citations is higher after retraction (3) than before retraction (1).

Discussion

General observations

The median number of days from publication to retraction was 337.5. Articles involving apparent misconduct took longer to retract (median of 386 days) than honest error (median of 184 days) as has been previously reported by others [28]. However, these times will all be overestimates of the *actual* time to retract because the issues leading to retraction are flagged after publication. For example, in one recent case, an article was retracted 11 years after publication due to a recent breach of editorial policy [29]. The actual time taken to retract was not itself 11 years, but shortly after the issue was raised.

Analysis of citations to articles before and after retraction revealed that articles continue to be cited after retraction as noted previously by others [30]. It is interesting that retracted articles continue to be cited much more than the retraction notices themselves which are rarely if ever cited (even though clearly linked to the original article). The fact that retraction notices are so seldom cited suggests that readers are unaware of the article's retraction [31].

Transparency of retraction notices

All BioMed Central journals have an over-arching retraction policy to retract articles where necessary so as to maintain the integrity of the published literature. Retraction notices published during the time frame of this study were identifiable as retractions, linked to the retracted article, identified the retracted article in the heading and explained the reason for the retraction in accordance with COPE guidelines [1]. While it was possible to classify retractions into discrete categories, in 15 notices (11%) it was not possible to distinguish the underlying issue, honest error or misconduct, which ultimately led to retraction. This may have been due to legal constraints or limited information available from institutions for editors to make the distinction between honest error and misconduct or perhaps simply due to oversight of the person writing the notice. In other cases retraction notices were ambiguous. For example, the stated reason for one retraction [27] was 'published in error' although the notice alludes to other problems with the data which likely also contributed to the retraction. Other articles were 'published in error' when a journal was transferred from another publisher and during this period an article was inadvertently published twice [20-22].

8 notices (6%) did not state clearly who was retracting the article. In such cases the retraction notices invariably simply stated 'This article is retracted due to' and it seems possibly the retraction could have come from the authors but was not explicit. These cases all occurred after the publication of the COPE guidelines on retraction and so the guidelines were not adhered to in this respect. In one case the retraction notice came from the journal this was likely an oversight and

potentially the retraction could have come from the Editor. While most retractions come from an individual i.e. the author or the Editor, in some cases authors and editors or editors and publishers had shared responsibility for the retractions.

In 5 cases (4%), retractions occurred because not all authors had been aware of the manuscript submission. Retractions due to authorship disputes are not recommended by COPE [1] because if the scientific integrity of the article is not affected it should be possible to resolve the issue by other means (for example by publishing a correction). However, authorship disputes can sometimes be symptomatic of other more serious underlying issues such as data theft. Retractions *solely* due to a lack of awareness or agreement on behalf of all authors has not occurred at BioMed Central since 2009 when the COPE guidelines were published. It is possible that this is because straightforward authorship issues can be addressed by the publication of a correction and complicated disputes are eventually retracted for different reasons.

In summary it is clear that COPE guidelines on retraction [1] were not adhered to in all respects. Others have also raised this issue and called for the role of publishers in the process to be clarified [31]. In order to further improve the transparency of retraction notices publishers could enforce the use of an internal checklist capturing the main information required in a retraction notice along with template wording as previously proposed [10,11].

Reasons for retraction

The majority of retractions were a result of misconduct, as found in other larger studies (3, 13, 28). However, definitions of misconduct vary and while many agree that fabrication, falsification and plagiarism are serious forms of misconduct we ultimately adopted a broader definition here and included other forms of misconduct (for example, manipulations to the peer review system which resulted in compromised peer review) - see Table 2. In the absence of clear definitions for 'what constitutes misconduct' others acknowledge there is a spectrum of lessor forms of misconduct which comprise "questionable research practices" [32]. For clarity in this study we focus on the individual reasons for retraction.

Compromised peer review did not occur as a reason to retract at BioMed Central prior to 2014 (Figure 2). However, the majority of cases reported here date to a set of retractions in March 2015 related to attempts to positively influence the outcome of peer review process of several journals by authors or third party agencies suggesting fabricated reviewers [7].

Plagiarism was found to be the second main reason for retraction (Table 2) and has also been a predominant reason for retraction highlighted in other studies [3]. The rise in software to detect plagiarism (alongside development of sophisticated approaches to check figure manipulation [33]) has gone hand-in-hand with a rise in retractions due to plagiarism in recent years [13]. While the use of anti-plagiarism software before publication may prevent the occurrence of retractions due to plagiarism in future, we have seen cases where authors disguise the plagiarism, for example, by substituting different key words to evade detection. Often it is the order of identical references within a section of text, rather than the exact words used that reveals that plagiarism has occurred. Also peer reviewers frequently detect "disguised plagiarism" more accurately than software programmes given their familiarity with previously published literature.

The third main reason for retraction was that the published data has subsequently been found to be unreliable in some way. Thirteen articles (10%) of retractions were due to problems with the data. Often these issues occurred through honest error in how the data were handled, for example [34, 35] although in some cases it is difficult to determine whether honest error or misconduct was the cause. Recent initiatives towards increased transparency and reproducible research through encouraging sharing and deposition of data prior to publication [36-38] could have an impact on reducing instances of retraction due to errors with the data in future. In preparing data to be "publication-ready" many issues may be caught and fixed before publication.

In some cases notices related to misconduct were transparent (for example [39]), in other cases less so. Several retractions were due to lack of appropriate ethical approvals (5 articles, 4%) or permission to use data (5 articles, 4%). It is difficult to pinpoint measures that Editors or reviewers can take to detect fraudulent and unethical practices *before* publication or even prevent them happening at all [40]. However, having policies in place to encourage explicit author contributions, declaration of conflicts of interests (for authors and reviewers), data sharing, adherence to reporting guidelines and ensuring the correct ethical approvals and permissions to publish data were obtained are vital. Most recently, the *BMJ* introduced a 'transparency declaration', requiring the lead author to confirm that the manuscript is an honest, accurate, and transparent account of the study being reported [41]. It will be interesting to see if this has any effect on reducing retractions in future. While the decision to act unethically rests with the researcher [42], the tremendous pressures that continue to be placed on researchers to 'publish or perish' [43, 44] may unintentionally fuel acts of misconduct [8, 45]. Clearly, there is a real need for integrity and transparency at all levels, from those in research (researchers and their institutions) to those making editorial recommendations (peer reviewers and editors) as previously suggested [42].

Conclusions

We found that COPE guidelines on retraction were adhered to in that an explicit reason for retraction was given in all cases of retraction evaluated from 2000-2015. Retractions were also readily identifiable, linked to the retracted article and identified the retracted article in the heading. However, in some cases notices did not document who issued the notice and there were ambiguities as to the underlying cause (honest error or misconduct). In future, we agree with others that adopting a checklist (linking to COPE guidelines) and a standard template formats for various classes of retraction notices would facilitate increased transparency and consistency of retraction notices. There may also be a need for making the retraction notice more obvious on the original article [31] given that the retracted articles are always more highly cited than the retraction notice, post retraction.

In general, across the publishing industry, Editors are adopting procedures and policies which may help to reduce certain classes of retraction in future. For example, many journals now screen for plagiarism and image manipulation and so we would predict a fall in retraction due to these issues in coming years. By encouraging data sharing and data deposition prior to publication authors collate their data to make it "publication-ready" and this exercise in itself can help resolve honest errors. However, robust publication ethics does not fall solely to Editors. Publication ethics is inclusive – authors, peer reviewers, editors, publishers and institutions all have their part to play to foster a culture of trust and transparency and maintain the integrity of the published literature.

Authors' contributions

ECM and MKK designed the study, collated and classified the data. MKK analysed the data. Both authors contributed to the writing of the manuscript and its revision. Both authors approved the final version. Both authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Competing interests

Both authors have completed the ICMJE uniform disclosure form and declare we are employed by BioMed Central. Since the manuscript has been revised ECM has been co-opted as a COPE Council Member, but this study did not involve COPE. We declare no other relationships or activities that could appear to have influenced the submitted work.

Data sharing

The full data set containing the descriptions of the retraction notices is provided in the accompanying additional file (Supplementary File 1) and can be accessed there.

Transparency

The lead author (the manuscript's guarantor) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Figures

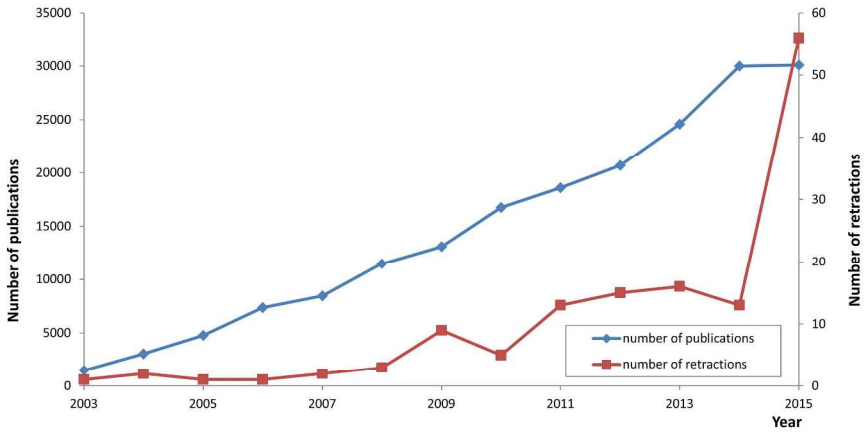
Figure 1. Growth in retractions compared to growth in total articles published (excluding supplements, corrections, retractions and commissioned content).

Figure 2. Growth in retractions showing variation in reasons for retracting articles from 2000 – 2015.

Supplementary files

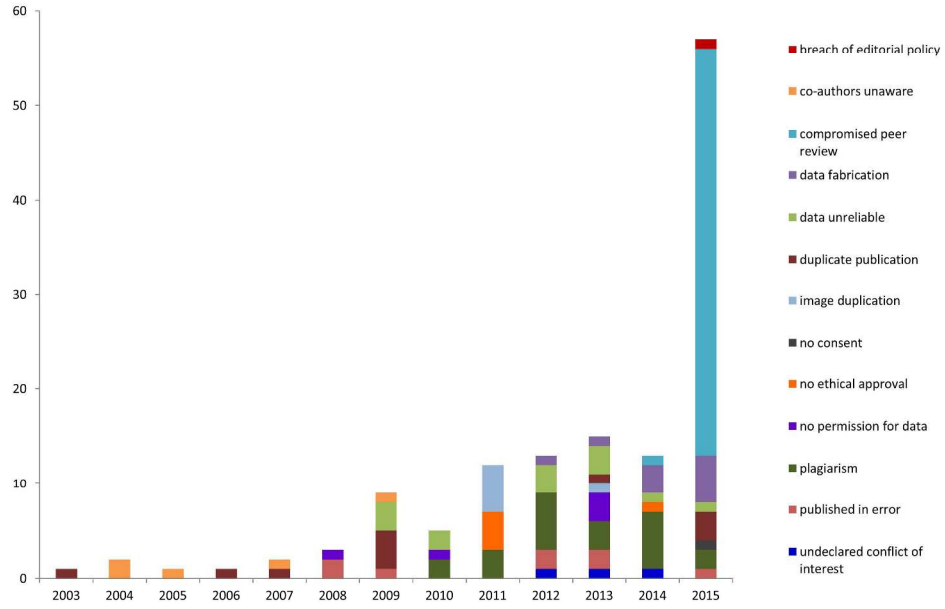
Supplementary file 1. Data set of retractions (Raw data for BMJ Open 2016)

Supplementary file 2. STROBE checklist.



Growth in retractions compared to growth in total articles published (excluding supplements, corrections, retractions and commissioned content).

254x190mm (300 x 300 DPI)



Growth in retractions showing variation in reasons for retracting articles from 2000 – 2015.

254x190mm (300 x 300 DPI)

link to retraction notice	Citations before retraction (in Scopus)	Citations after retraction (in Scopus)	retraction cited?	Journal	date article published	date retraction posted	# days between publication and retraction	Reason for retraction	Who retracted	year retraction posted
http://www.arthritis-research.com/content/17/1/354	49	2	0	*Arthritis Research &Therapy*	20/09/2011	09/12/2015	1541	data fabrication	authors	2015
http://www.scoliosisjournal.com/content/10/1/34	0	1	0	*Scoliosis*	12/06/2015	03/12/2015	174	published in error	authors and editor	2015
http://www.jneuroinflammation.com/content/12/1/220	7	3	0	*Journal of Neuroinflammation*	22/01/2014	26/11/2015	673	data fabrication	Editor	2015
http://bmcophthalmol.biomedcentral.com/articles/10.1186/s12886-015-0114-z	3	2	0	*BMC Opthalmology*	09/04/2013	16/11/2015	951	duplicate publication	Editor	2015
http://bmcevolbiol.biomedcentral.com/articles/10.1186/s12862-015-0513-z	830	12	0	*BMC Evolutionary Biology*	28/06/2004	05/11/2015	4147	breach of editorial policy	Editor	2015
http://bmcgenomics.biomedcentral.com/articles/10.1186/s12864-015-1802-z	2	1	0	*BMC Genomics*	11/12/2014	03/08/2015	235	data unreliable	authors	2015
http://particleandfibretoxicology.biomedcentral.com/articles/10.1186/s12989-015-0097-1	23	6	0	*Particle and Fibre Toxicology*	13/02/2013	14/07/2015	881	data fabrication	Editor	2015
http://particleandfibretoxicology.biomedcentral.com/articles/10.1186/s12989-015-0098-0	1	4	0	*Particle and Fibre Toxicology*	12/09/2014	14/07/2015	305	data fabrication	Editor	2015
http://diagnosticpathology.biomedcentral.com/articles/10.1186/s13000-015-0240-1	0	1	1	*Diagnostic Pathology*	01/07/2014	26/03/2015	268	compromised peer review	Publisher & Editor	2015
http://cancerci.biomedcentral.com/articles/10.1186/s12935-015-0199-8	0	1	0	*Cancer Cell International*	19/12/2014	24/06/2015	187	compromised peer review	Publisher & Editor	2015
http://bmcmusculoskeletdisord.biomedcentral.com/articles/10.1186/s12891-015-0462-0	4	1	0	*BMC Musculoskeletal Disorders*	17/11/2009	19/06/2015	2040	plagiarism	Editor	2015
http://diagnosticpathology.biomedcentral.com/articles/10.1186/s13000-015-0237-9	0	1	0	*Diagnostic Pathology*	26/09/2014	13/05/2015	229	compromised peer review	Publisher & Editor	2015
http://aacijournal.biomedcentral.com/articles/10.1186/s13223-015-0079-8	not in scopus	?	?	*Allergy, Asthma & Clinical Immunology*	18/12/2014	17/04/2015	120	duplicate publication	authors	2015
http://jehse.biomedcentral.com/articles/10.1186/s40201-015-0182-2	0	1	0	*Journal of Environmental Health Science and Engineering*	27/12/2014	17/04/2015	111	duplicate publication	Editor	2015

http://rbej.biomedcentral.com/articles/10.1186/s12958-015-0016-1	13	1	0	*Reproductive Biology and Endocrinology*	16/12/2003	03/04/2015	4126	data fabrication	Editor	2015
http://www.eurjmedres.com/content/20/1/44	15	1	0	*European Journal of Medical Research*	30/07/2013	31/03/2015	609	compromised peer review	Publisher & Editor	2015
http://www.cardiothoracicsurgery.org/content/10/1/42	0	1	0	*Journal of Cardiothoracic Surgery*	05/12/2014	27/03/2015	112	compromised peer review	Publisher & Editor	2015
http://www.cardiothoracicsurgery.org/content/10/1/43	6	2	0	*Journal of Cardiothoracic Surgery*	28/02/2014	27/03/2015	392	compromised peer review	Publisher & Editor	2015
http://diagnosticpathology.biomedcentral.com/articles/10.1186/s13000-015-0239-7	0	1	0	*Diagnostic Pathology*	17/06/2013	26/03/2015	647	compromised peer review	Publisher & Editor	2015
http://ovarianresearch.biomedcentral.com/articles/10.1186/s13048-015-0147-1	1	1	0	*Journal of Ovarian Research*	17/12/2013	26/03/2015	464	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/33	1	1	0	*European Journal of Medical Research*	21/03/2014	26/03/2015	370	compromised peer review	Publisher & Editor	2015
http://ovarianresearch.biomedcentral.com/articles/10.1186/s13048-015-0145-3	1	2	0	*Journal of Ovarian Research*	21/01/2014	26/03/2015	429	compromised peer review	Publisher & Editor	2015
http://bmcmusculoskeletdisord.biomedcentral.com/articles/10.1186/s12891-015-0528-z	2	1	0	*BMC Musculoskeletal Disorders*	22/05/2014	26/03/2015	308	compromised peer review	Publisher & Editor	2015
http://www.jmedicalcasereports.com/content/9/1/70	0	1	0	*Journal of Medical Case Reports*	26/03/2014	26/03/2015	365	no consent	Editor	2015
http://bmcgastroenterol.biomedcentral.com/articles/10.1186/s12876-015-0265-7	0	1	0	*BMC Gastroenterology*	03/04/2014	26/03/2015	357	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/40	0	1	0	*European Journal of Medical Research*	14/12/2013	26/03/2015	467	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/34	0	1	0	*European Journal of Medical Research*	10/12/2013	26/03/2015	471	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/39	4	6	0	*European Journal of Medical Research*	06/12/2013	26/03/2015	475	compromised peer review	Publisher & Editor	2015

http://www.eurjmedres.com/content/20/1/37	0	1	0	*European Journal of Medical Research*	29/10/2014	26/03/2015	148	compromised peer review	Publisher & Editor	2015
http://diagnosticpathology.biomedcentral.com/articles/10.1186/s13000-015-0238-8	14	7	0	*Diagnostic Pathology*	21/10/2013	26/03/2015	521	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/43	0	1	0	*European Journal of Medical Research*	01/09/2013	26/03/2015	571	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/32	1	1	0	*European Journal of Medical Research*	27/12/2013	26/03/2015	454	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/36	1	1	0	*European Journal of Medical Research*	29/05/2014	26/03/2015	301	compromised peer review	Publisher & Editor	2015
http://wjso.biomedcentral.com/articles/10.1186/s12957-015-0547-0	4	4	0	*World Journal of Surgical Oncology*	10/12/2013	26/03/2015	471	compromised peer review	Publisher & Editor	2015
http://diagnosticpathology.biomedcentral.com/articles/10.1186/s13000-015-0241-0	1	1	0	*Diagnostic Pathology*	26/09/2014	26/03/2015	181	compromised peer review	Publisher & Editor	2015
http://ovarianresearch.biomedcentral.com/articles/10.1186/s13048-015-0144-4	0	3	0	*Journal of Ovarian Research*	30/09/2014	26/03/2015	177	compromised peer review	Publisher & Editor	2015
http://bmccancer.biomedcentral.com/articles/10.1186/s12885-015-1162-8	3	3	0	*BMC Cancer*	16/01/2014	26/03/2015	434	compromised peer review	Publisher & Editor	2015
http://bmccardiovascdisord.biomedcentral.com/articles/10.1186/s12872-015-0019-z	2	2	0	*BMC Cardiovascular Disorders*	17/04/2014	26/03/2015	343	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0183-y	3	1	0	*Journal of Orthopaedic Surgery and Research*	11/04/2014	26/03/2015	349	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0180-1	1	1	0	*Journal of Orthopaedic Surgery and Research*	16/08/2014	26/03/2015	222	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0179-7	0	1	0	*Journal of Orthopaedic Surgery and Research*	10/03/2014	26/03/2015	381	compromised peer review	Publisher & Editor	2015

http://bmcneurol.biomedcentral.com/articles/10.1186/s12883-015-0307-3	3	1	0	*BMC Neurology*	20/11/2013	26/03/2015	491	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/38	3	2	0	*European Journal of Medical Research*	20/12/2013	26/03/2015	461	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/30	2	1	0	*European Journal of Medical Research*	04/10/2013	26/03/2015	538	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/35	6	2	0	*European Journal of Medical Research*	17/12/2013	26/03/2015	464	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/42	2	5	0	*European Journal of Medical Research*	23/04/2014	26/03/2015	337	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/31	2	1	0	*European Journal of Medical Research*	14/11/2013	26/03/2015	497	compromised peer review	Publisher & Editor	2015
http://www.eurjmedres.com/content/20/1/41	0	3	0	*European Journal of Medical Research*	20/08/2014	26/03/2015	218	compromised peer review	Publisher & Editor	2015
http://diagnosticpathology.biomedcentral.com/articles/10.1186/s13000-015-0236-x	3	1	0	*Diagnostic Pathology*	23/08/2013	26/03/2015	580	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0176-x	1	2	0	*Journal of Orthopaedic Surgery and Research*	15/04/2014	26/03/2015	345	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0182-z	0	1	0	*Journal of Orthopaedic Surgery and Research*	12/12/2014	26/03/2015	104	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0178-8	1	1	0	*Journal of Orthopaedic Surgery and Research*	23/04/2014	26/03/2015	337	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0181-0	0	1	0	*Journal of Orthopaedic Surgery and Research*	17/03/2014	26/03/2015	374	compromised peer review	Publisher & Editor	2015

http://www.eurjmedres.com/content/20/1/29	1	1	0	*European Journal of Medical Research*	16/09/2014	26/03/2015	191	compromised peer review	Publisher & Editor	2015
http://ovarianresearch.biomedcentral.com/articles/10.1186/s13048-015-0146-2	3	6	1	*Journal of Ovarian Research*	06/12/2013	26/03/2015	475	compromised peer review	Publisher & Editor	2015
http://josr-online.biomedcentral.com/articles/10.1186/s13018-015-0177-9	0	0	0	*Journal of Orthopaedic Surgery and Research*	21/02/2014	26/03/2015	398	compromised peer review	Publisher & Editor	2015
http://bmcsurg.biomedcentral.com/articles/10.1186/1471-2482-15-2	14	2	0	*BMC Surgery*	08/10/2013	14/01/2015	463	plagiarism	authors	2015
http://www.biomedcentral.com/1756-0500/7/868	0	3	0	*BMC Research Notes*	21/01/2014	25/11/2014	308	no ethical approval	editor	2014
http://www.annals-general-psychiatry.com/content/13/1/30	0	1	0	*Annals of General Psychiatry*	12/04/2014	26/11/2014	228	plagiarism	authors	2014
http://www.translationalneurodegeneration.com/content/3/1/22	1	2	0	*Translational Neurodegeneration*	27/08/2014	03/10/2014	37	undeclared conflict of interest	Editor	2014
http://www.nutritionandmetabolism.com/content/11/1/43	0	2	0	*Nutrition & Metabolism*	06/06/2014	24/09/2014	110	plagiarism	editor	2014
http://www.biomedcentral.com/1752-0509/8/105	13	8	0	*BMC Systems Biology*	21/03/2012	18/09/2014	911	compromised peer review	editor	2014
http://www.biomedcentral.com/1471-2393/14/202	1	4	2	*BMC Pregnancy and Childbirth*	12/08/2013	03/07/2014	325	data unreliable	authors	2014
http://www.dmsjournal.com/content/6/1/60	2	7	0	*Diabetology & Metabolic Syndrome*	02/09/2013	27/05/2014	267	plagiarism	editor	2014
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http://www.molecularpain.com/content/10/1/20	8	2	0	*Molecular Pain*	11/01/2012	02/04/2014	812	data fabrication	authors	2014
http://www.ijponline.net/content/40/1/9	7	5	0	*Italian Journal of Pediatrics*	23/07/2012	11/03/2014	596	plagiarism	authors	2014
http://www.nutritionandmetabolism.com/content/11/1/11	32	14	1	*Nutrition & Metabolism*	18/10/2008	14/02/2014	1945	plagiarism	editor	2014
http://www.retrovirology.com/content/11/1/16	not in scopus	?	0	*Retrovirology*	13/09/2012	06/02/2014	511	data fabrication	authors	2014
http://www.biomedcentral.com/1472-6793/13/13	17	3	0	*BMC Physiology*	12/05/2010	10/01/2014	1339	data fabrication	authors	2014
http://www.biomedical-engineering-online.com/content/12/1/113	7	2	0	*BioMedical Engineering OnLine*	05/05/2004	06/12/2013	3502	image duplication	publisher	2013

http://www.cancerci.com/content/13/1/96	2	4	0	*Cancer Cell International*	29/05/2012	22/10/2013	511	data unreliable	authors	2013
http://www.biomedcentral.com/1756-0500/6/422	1	5	0	*BMC Research Notes*	23/02/2012	18/10/2013	603	no permission for data	editor	2013
http://www.biomedcentral.com/1756-0500/6/332	0	1	0	*BMC Research Notes*	06/05/2013	20/08/2013	106	data unreliable	authors	2013
http://www.diagnosticpathology.org/content/8/1/127	2	13	0	*Diagnostic Pathology*	07/12/2012	14/08/2013	250	plagiarism	authors	2013
http://www.aacijournal.com/content/9/1/28	not in scopus	?	1	*Allergy, Asthma & Clinical Immunology*	15/07/2013	12/08/2013	28	no permission for data	authors	2013
http://www.biomedcentral.com/1472-6750/13/57	4	5	1	*BMC Biotechnology*	06/01/2011	20/07/2013	926	data fabrication	authors	2013
http://www.skeletalmusclejournal.com/content/3/1/15	?	?	0	*Skeletal Muscle*	27/04/2012	18/07/2013	447	data unreliable	authors	2013
http://www.translational-medicine.com/content/11/1/144	0	8	0	*Journal of Translational Medicine*	05/12/2012	11/06/2013	188	published in error	publisher	2013
http://www.biomedcentral.com/1472-6963/13/180	0	1	0	*BMC Health Services Research*	21/12/2012	20/05/2013	150	no permission for data	authors	2013
http://www.jdmdonline.com/content/12/1/21	0	2	0	*Journal of Diabetes & Metabolic Disorders*	22/12/2012	14/05/2013	143	published in error	publisher	2013
http://www.scoliosisjournal.com/content/8/1/7	0	2	0	*Scoliosis*	28/05/2012	03/05/2013	340	undeclared conflict of interest	editor	2013
http://www.proteomesci.com/content/11/1/16	5	3	0	*Proteome Science*	02/06/2011	23/04/2013	691	plagiarism	editor	2013
http://www.jdmdonline.com/content/11/1/21	0	2	6	*Journal of Diabetes & Metabolic Disorders*	24/08/2012	07/03/2013	195	duplicate publication	not stated	2013
http://www.jasbsci.com/content/4/1/3	0	21	0	*Journal of Animal Science and Biotechnology*	22/08/2012	23/01/2013	154	plagiarism	authors	2013
http://www.biomedcentral.com/1472-6882/12/206	1	22	0	*BMC Complementary and Alternative Medicine*	20/09/2011	02/11/2012	409	plagiarism	journal	2012
http://breast-cancer-research misconduct.com/content/14/5/402	0	9	1	*Breast Cancer Research*	06/03/2012	31/10/2012	239	data unreliable	authors	2012
http://www.gvt-journal.com/content/10/1/10	0	0	1	*Genetic Vaccines and Therapy*	20/06/2012	23/10/2012	125	undeclared conflict of interest	editor	2012

http://www.jnanobiotechnology.com/content/10/1/40	0	22	0	*Journal of Nanobiotechnology*	20/07/2012	04/10/2012	76	plagiarism	not stated	2012
http://www.wjso.com/content/10/1/196	6	17	2	*World Journal of Surgical Oncology*	30/04/2010	20/09/2012	874	plagiarism	authors	2012
http://www.molecular-cancer.com/content/11/1/57	56	30	1	*Molecular Cancer*	23/03/2006	20/08/2012	2342	plagiarism	authors	2012
http://www.biomedcentral.com/1471-2121/13/17	0	1	0	*BMC Cell Biology*	26/03/2012	26/06/2012	92	plagiarism	editor	2012
http://www.biomedcentral.com/1756-0500/5/319	0	5	0	*BMC Research Notes*	20/12/2011	21/06/2012	184	published in error	editor	2012
http://www.celldiv.com/content/7/1/15	5	13	0	*Cell Division*	21/01/2010	15/05/2012	845	plagiarism	not stated	2012
http://www.ctajournal.com/content/2/1/6	not in scopus	?	?	*Clinical and Translational Allergy*	25/08/2011	16/03/2012	204	data unreliable	authors	2012
http://www.jeccr.com/content/31/1/21	0	3	0	*Journal of Experimental & Clinical Cancer Research*	10/11/2011	13/03/2012	124	data unreliable	authors	2012
http://www.cardiothoracicsurgery.org/content/7/1/17	1	4	0	*Journal of Cardiothoracic Surgery*	12/05/2011	06/03/2012	299	published in error	editor	2012
http://www.biomedcentral.com/1471-2172/13/3	0	0	0	*BMC Immunology*	11/11/2011	16/01/2012	66	data fabrication	authors	2012
http://www.retrovirology.com/content/8/1/88	0	4	2	*Retrovirology*	06/01/2011	05/11/2011	303	image duplication	authors	2011
http://www.wjso.com/content/9/1/136	0	2	1	*World Journal of Surgical Oncology*	13/07/2011	24/10/2011	103	plagiarism	authors	2011
http://www.chiromt.com/content/19/1/24	2	1	0	*Chiropractic & Manual Therapies*	09/08/2010	03/10/2011	420	no ethical approval	not stated	2011
http://www.biomedcentral.com/1746-6148/7/56	0	9	1	*BMC Veterinary Research*	29/04/2011	20/09/2011	144	plagiarism	authors	2011
http://www.biomedcentral.com/1471-2474/12/200	3	6	0	*BMC Musculoskeletal Disorders*	08/04/2010	13/09/2011	523	no ethical approval	not stated	2011
http://www.biomedcentral.com/1471-2474/12/158	4	13	0	*BMC Musculoskeletal Disorders*	17/04/2009	13/07/2011	817	no ethical approval	not stated	2011
http://www.biomedcentral.com/1471-2474/12/159	0	5	0	*BMC Musculoskeletal Disorders*	19/10/2010	13/07/2011	267	no ethical approval	not stated	2011
http://www.biomedcentral.com/1471-2164/12/284	6	25	0	*BMC Genomics*	28/09/2009	02/06/2011	612	image duplication	authors	2011

http://www.biomedcentral.com/1471-2180/11/128	7	13	1	*BMC Microbiology*	12/02/2009	02/06/2011	840	image duplication	editor	2011
http://www.biomedcentral.com/1471-2180/11/127	0	3	0	*BMC Microbiology*	05/01/2010	02/06/2011	513	image duplication	editor	2011
http://www.jeccr.com/content/30/1/19	1	10	1	*Journal of Experimental & Clinical Cancer Research*	11/10/2010	16/02/2011	128	plagiarism	authors	2011
http://www.retrovirology.com/content/8/1/1	19	10	0	*Retrovirology*	09/04/2006	06/01/2011	1733	image duplication	authors	2011
http://www.biomedcentral.com/1472-6939/11/20	0	3	0	*BMC Medical Ethics*	15/09/2010	21/12/2010	97	plagiarism	authors	2010
http://www.parasitesandvectors.com/content/3/1/78	0	2	0	*Parasites & Vectors*	24/06/2010	25/08/2010	62	data unreliable	editor	2010
http://www.virologyj.com/content/7/1/190	0	1	0	*Virology Journal*	21/07/2010	13/08/2010	23	data unreliable	editor	2010
http://www.biomedcentral.com/1471-2105/11/258	0	1	0	*BMC Bioinformatics*	18/01/2010	18/05/2010	120	plagiarism	not stated	2010
http://www.cmjournal.org/content/5/1/10	0	2	0	*Chinese Medicine*	27/11/2009	16/03/2010	109	no permission for data	authors	2010
www.jmedicalcasereports.com/content/3/1/122	0	4	0	*Journal of Medical Case Reports*	31/07/2008	13/11/2009	470	published in error	publisher	2009
http://www.molecularneurodegeneration.com/content/4/1/45	2	6	0	*Molecular Neurodegeneration*	01/10/2007	04/11/2009	765	data unreliable	authors	2009
http://www.biomedcentral.com/1472-6947/9/45	0	3	0	*BMC Medical Informatics and Decision Making*	09/11/2007	20/10/2009	711	data unreliable	editor	2009
www.microbialcellfactories.com/content/8/1/52	not in scopus	?	?	*Microbial Cell Factories*	20/07/2009	15/10/2009	87	duplicate publication	authors	2009
http://www.molecular-cancer.com/content/8/1/84	0	5	0	*Molecular Cancer*	27/09/2009	14/10/2009	17	duplicate publication	authors	2009
http://www.jeccr.com/content/28/1/137	1	8	0	*Journal of Experimental & Clinical Cancer Research*	16/07/2009	09/10/2009	85	duplicate publication	authors	2009
http://www.jeccr.com/content/28/1/101	2	14	0	*Journal of Experimental & Clinical Cancer Research*	12/08/2008	16/07/2009	338	duplicate publication	authors	2009
http://www.issoonline.com/content/6/1/11	0	3	0	*International Seminars in Surgical Oncology*	05/02/2009	17/04/2009	71	co-authors unaware	authors	2009

http://www.hqlo.com/content/7/1/34	0	4	1	*Health and Quality of Life Outcomes*	30/01/2009	17/04/2009	77	data unreliable	authors	2009
http://www.biomedcentral.com/1471-2342/8/15	0	4	2	*BMC Medical Imaging*	31/01/2007	11/08/2008	558	no permission for data	authors	2008
http://www.jautoimdis.com/content/5/1/5	0	12	0	*Journal of Autoimmune Diseases*	29/07/2008	11/08/2008	13	published in error	publisher	2008
http://www.carcinogenesis.com/article.asp?issn=1477-3163;year=2008;volume=7;issue=1;spage=4;epage=4;aulast=Weiner	0	4	0	*Journal of Carcinogenesis*	28/07/2008	08/08/2008	11	published in error	publisher	2008
http://www.virologyj.com/content/4/1/119	0	6	0	*Virology Journal*	24/09/2007	31/10/2007	37	co-authors unaware	authors	2007
http://www.josr-online.com/content/2/1/6	0	4	1	*Journal of Orthopaedic Surgery and Research*	02/11/2006	04/04/2007	153	duplicate publication	authors	2007
http://www.cardiovascularultrasound.com/content/4/1/42	0	6	0	*Cardiovascular Ultrasound*	16/10/2006	08/11/2006	23	duplicate publication	authors	2006
http://www.molecular-cancer.com/content/4/1/17	0	3	2	*Molecular Cancer*	05/04/2005	06/05/2005	31	co-authors unaware	authors	2005
http://www.molecular-cancer.com/content/3/1/1	0	10	0	*Molecular Cancer*	23/09/2003	14/01/2004	113	co-authors unaware	authors	2004
http://www.molecular-cancer.com/content/3/1/2	0	6	0	*Molecular Cancer*	07/08/2003	14/01/2004	160	co-authors unaware	authors	2004
http://www.molecular-cancer.com/content/2/1/17	0	10	0	*Molecular Cancer*	03/01/2003	03/03/2003	59	duplicate publication	authors	2003

Strobe checklist for reporting observational studies

http://www.who.int/bulletin/volumes/85/11/07-045120.pdf

Item	Item number	Recommendation	Page number in ms
Title & Abstract	1	a) Retrospective cross-sectional b) available retraction notices were assessed to record the reasons for retraction and whether they adhered to COPE guidelines (as stated in the abstract)	1&2
Introduction Background/rationale	2	To assess all retraction notices from BioMed Central to determine causes of retraction and whether notices were transparent and adhered to COPE guidelines	3
Objectives	3	• To find out reasons why BioMed Central retracted articles • Whether COPE guidelines were followed • Whether retractions were increasing	1
Methods Study design	4	Retrospective cross-sectional study of all retractions published by BioMed Central between 2000-2015. This time period is from when BioMed Central first started publishing retractions (in 2000) up to 2015 (to have 15 complete years of data).	4
Setting	5	All retractions published by BioMed Central, between January 2000 (when the first retractions began to be published) until December 2015 (which represented 15 years of	4

		data).	
Participants	6	The participants in this study were 134 articles (published across various BioMed Central journals by different authors, in different disciplines) that had been retracted by BioMed Central in the above timeframe. The articles were identified using the publisher's publically available advanced search function using the search term 'retraction' within the article title. Retractions were excluded if they were published by other publishers before the journal was transferred to BioMed Central as we were interested in analysing BioMed Central-written retraction notices. Elizabeth Moylan conducted the search for retracted articles.	4
Variables	7	When retractions are published at BioMed Central they must all state 'Retraction' in the title (it is a specific article type determined by the production department). We are confident no retraction articles have been missed as the search term used 'retraction'. Any false positives, i.e. articles which included the word retraction but were not themselves retractions were excluded by Elizabeth Moylan.	4
Data sources/measurements	8	Who issued the retraction notice and the reason for retraction were recorded. The time elapsed between publication of the original article and publication of the	4

		retraction notice was also recorded. Retractions were broadly classified according to the apparent underlying reason for the retraction into the following categories: honest error, misconduct (see manuscript for further discussion). Where it was not possible to distinguish 'honest error' from 'misconduct', the retraction notice was scored as 'unclear'. Where a retraction notice mentioned irregularities in the data and an institutional investigation the notice was scored as misconduct unless honest error was explicitly mentioned. Where multiple reasons for the retraction were given the main reason was scored and the secondary reasons were noted. The scoring of the retraction notices is given in Supplementary File 1. Citations for all retracted articles were counted before and after the date of retraction by searching for the article or authors in Scopus accessed on 26/2/2016. Citations to the retraction notice were also counted. Citation data are also provided in Supplementary File 1.	
Bias	9	All notices were classified by one author (EM) and checked for agreement by the other author (MK) using the information given in the retraction notice alone (i.e. no additional information was used). Where there was a difference in opinion, a discussion took place between the authors to reach a consensus.	4

Study size	10	The study is limited by the number of retractions that occurred (and are available to analyse) between January 2000 and December 2015.	3
Quantitative variables	11	Individual reasons for retraction were described as given in Table 2 of the manuscript	8
Statistical methods	12	Retraction notices were classified and analysed in excel and total numbers (and percentages) reported. Descriptive statistics (means and percentages) was used to analyse the results.	6
Results			
Participants	13	134 retraction notices were published between January 2000 and December 2015 and eligible for analysis.	6
Descriptive data	14	All retractions were analysed. The classification is given in Supplementary File 1.	(see supplementary file 1)
Outcome data	15	Table 1 in the manuscript shows who retracted the various notices. Table 2 in the manuscript shows the reasons for the retractions.	6 8
Main results	16	The most common reason for retraction is compromised peer review (44, 33%), followed by plagiarism (22, 16%) followed by problems with the data - i.e. the data was found to be 'unreliable' (13, 10%). Other reasons include lack of appropriate ethical approvals or permission to use data (5 or 4% in each case), duplicate publication (11, 8%), publication in error (8, 6%), image manipulation	7

		(6, 4%), or because of a lack of awareness by some authors of the manuscript's submission and publication (5, 4%). 10 (7%) of retractions were due to data falsification/fabrication. 3 (2%) of retractions were due to undeclared conflicts of interest.	
Other analyses	17	Citations for all retracted articles were counted before and after the date of retraction by searching for the article or authors in Scopus accessed on 26/2/2016. Citations to the retraction notice were also counted. Citation data are provided in Supplementary File 1. Median number of days from publication to retraction was 337.5. Articles involving apparent misconduct took longer to retract (median of 386 days) than honest error (median of 184 days) as previously reported. It took between 11 and 4147 days to retract an article.	(see supplementary file 1) 6
Discussion Key results	18	The majority of retractions were a result of misconduct, as found in other larger studies. However, within this category, compromised peer review was the predominant reason (Table 2). Plagiarism was found to be the second main reason for retraction (Table 2) and has also been a predominant reason for retraction highlighted in other studies. The third main	8

		reason for retraction was that the published data has subsequently been found to be unreliable in some way. 13 (10%) of retractions were due to problems with the data. For all retraction notices a descriptive reason for each retraction was always given. However, in 15 (11%) of notices it was not possible to distinguish the underlying issue, honest error or misconduct, which ultimately led to retraction. This may have been due to legal constraints or limited information available from institutions for editors to make the distinction between honest error and misconduct. In other cases retraction notices were ambiguous. COPE guidelines were adhered to in so far as a clear reason for each retraction was given. However, 8 (6%) of notices did not state clearly who was retracting the article. These cases all occurred after the publication of the COPE guidelines on retraction which were not adhered to in this respect.	10 10
Limitations	19	The study is limited by the number of retractions available to analyse and because of this any correlations of retractions with a particular journal, article type, discipline or peer review model have not been explored.	3

Interpretation	20	To reduce bias in how retraction notices were classified they were first described by one author (EM) and checked for agreement by the other author (MK) using the information given in the retraction notice alone. Where there was a difference in opinion, a discussion took place between the authors to reach a consensus.	4
Generalizability	21	The majority of retractions were a result of misconduct, as found in other larger studies. We found that COPE guidelines on retraction were adhered to in that an explicit reason for retraction was given in all cases of retraction evaluated from 2000-2015. However, in some cases notices did not document who issued the notice and there were ambiguities as to the underlying cause (honest error or misconduct). The findings reported here have also been documented in large scale studies. We do not know the extent to which the findings of one publisher may generalize to another publisher but we would suspect that a majority of retractions would be due to misconduct, namely plagiarism. We recommend that Publishers adopt a checklist (linking to COPE guidelines) and a standard template for various classes of retraction notices to facilitate increased transparency and consistency.	10-12

Other information Funding	22	This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.	13