Scientometrics (2013) 96:573–587
DOI 10.1007/s11192-012-0920-5

The impact of misconduct on the published medical and non-medical literature, and the news media

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Received: 8 October 2012 / Published online: 9 December 2012

Abstract Better understanding of research and publishing misconduct can improve strategies to mitigate their occurrence. In this study, we examine various trends among 2,375 articles retracted due to misconduct in all scholarly fields. Proportions of articles retracted due to "publication misconduct" (primarily plagiarism and duplicate publication) or "distrust data or interpretations" (primarily research artifacts and unexplained irreproducibility of data) differ significantly between PubMed (35 and 59 %, respectively) and non-PubMed (56 and 27 %) articles and between English- and non-English-speaking author affiliation countries. Retraction rates due to any form of misconduct, adjusted for the size of the literature in different disciplines, vary from 0.22 per 100,000 articles in the Humanities to 7.58 in Medicine and 7.69 in Chemistry. The annual rate of article retractions due to misconduct has increased exponentially since 2001, and the percentage of all retractions involving misconduct allegations has grown from 18.5–29.2 % for each year from 1990–1993 to 55.8–71.9 % for each year from 2007–2010. Despite these increases, the prominence of research integrity in the news media has not changed appreciably over the past 20 years. Articles retracted due to misconduct are found in all major scholarly disciplines. The higher rate of plagiarism among authors from non-English speaking countries may diminish if institutions improved their support for the writing of English manuscripts by their scholars. The training of junior scholars on proper codes of research (and publishing) conduct should be embraced by all disciplines, not just by biomedical fields where the perception of misconduct is high.

Keywords Research misconduct · Plagiarism · PubMed · Non-PubMed · Scholarly disciplines

Electronic supplementary material The online version of this article (doi:10.1007/s11192-012-0920-5) contains supplementary material, which is available to authorized users.

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Introduction

Research integrity has been defined as: "a measure of the degree to which researchers adhere to the rules or laws, regulations, guidelines, and commonly accepted professional codes and norms of their respective research areas" (Steneck 2002); and *research misconduct* or *scientific misconduct* is behavior which violates such standards. To protect the integrity of science, research has increasingly focused on the impacts and mitigation of misconduct (e.g., Steen 2011; Alfredo and Hart 2011). The costs of research misconduct are very high in both economic (US$525,000 per case; Michalek et al. 2010) and human terms, as hundreds of thousands of patients have been enrolled in clinical studies that were based on findings later retracted (Steen 2011). Published editorials often focus on cases where the actions of an individual prompted dozens of retractions, and erroneously state or imply that these aberrant cases represent the norm (e.g., Anon 2010, 2011). Trends revealed by systematic studies of the publications retracted due to alleged misconduct can inform efforts to strengthen research integrity, though prior studies have all limited their scope to the PubMed database (see citations in Grieneisen and Zhang 2012; Fang et al. 2012). More comprehensive studies are necessary to understand the prominence and impacts of these issues outside of the medical literature.

Here we examine 2,375 articles spanning all scholarly fields which were retracted from 1928 to 2011 due to alleged misconduct in the performance or reporting of research. We consider the following attributes of these articles: the types of misconduct involved (as defined in "Materials and methods"), author affiliation countries, scholarly disciplines, and professional positions of the individuals involved (when known). We also quantified the prominence of scientific misconduct in the news media since 1980 to shed light on the impact of misconduct on public perception of research integrity. Based on trends in the data, we offer some policy suggestions for reducing the occurrence of misconduct and its impacts on both the published literature and the advancement of scientific knowledge.

Materials and methods

Most of the results reported here were derived from a subset of 2,375 articles retracted due to misconduct within a database of 4,449 retracted scholarly articles. The compilation of that database was described in a previous article (Grieneisen and Zhang 2012). Briefly, we defined "retracted articles" as those for which a notice calling for formal retraction had been issued by the journal in which the article was published or affected by a "Finding of Misconduct" notice from the Office of Research Integrity (ORI) and reported in *The Federal Register*. These notices may indicate either all or some of the authors, editors, "the publishers" or various ethics investigating authorities as calling for the retraction due to serious questions regarding the validity of data or interpretations as published.

The list of retracted articles was compiled based on queries in May–August 2011 of 42 data sources, including PubMed, Web of Science (WoS), other databases devoted to the published literature of individual scholarly disciplines (such as Biosis and MathSciNet), major publisher websites (e.g., ScienceDirect, SpringerLink), search engines (e.g., GoogleScholar, Scirus), and *The Federal Register*. A full list of sources and queries conducted are provided in our previous article (Grieneisen and Zhang 2012).

The queries yielded 4,449 articles retracted from 1928–2011; though only 12 were retracted prior to 1980 and data for 2011 represent only part of that year. We were able to obtain the retraction notices for 4,232 of them, and 4,244 of the retracted articles.

From the retraction notices and *Federal Register* reports, we obtained the justifications for retraction (explained in greater detail in the next paragraph) and year of retraction. From the articles we obtained the country affiliations of all authors listed. Scholarly disciplines were assigned to each article based on the WoS categories assigned to the journal in which it was published. The relative sizes of the published literature in each scholarly field were obtained by querying WoS for "publication year 1980–2010" and using the "Analyze Results" feature with the WoS categories option. All WoS categories (e.g., "Chemistry, Organic" and "Chemistry, Physical") within a scientific discipline (e.g., Chemistry) were selected in the analyze results screen and the "View Results" option yielded the number of WoS records for that discipline. We considered the "PubMed retractions" to be those appropriately identified as "Retracted publication" in the Publication Type field of their PubMed record. Data on the "repeat offenders," i.e., authors with 15 or more retracted articles, were obtained from Grieneisen and Zhang (2012).

The justifications for retraction of these articles are divided into two main categories in this study, consistent with the guidelines of the Committee on Publication Ethics (http://www.councilscienceeditors.org/files/presentations/2011/13_Wager.pdf- pp.4). "Publishing misconduct" (PM) involves cases of plagiarism, authorship disputes or author-initiated duplicate publication. It does not include cases where duplicate publication resulted from errors made by the editor or publisher. "Research misconduct" (RM) includes cases of alleged data fabrication or falsification, failure to obtain legally required approval of a study protocol by appropriate oversight authorities (usually an Institutional Review Board, IRB), or other intentional biasing of study design to obtain a desired outcome. A third category, "distrust data or interpretations," (DDI) includes all articles in which the integrity of data or its interpretation is questioned. DDI includes retractions motivated by alleged data fabrication or falsification, but is dominated by the "non-misconduct" justifications of experimental artifacts or unexplained irreproducibility of data. It also includes cases where authors no longer believe their published interpretations (even if they believe the data is sound) in light of new information. Articles "retracted due to misconduct" include only those where either the retraction notice or *The Federal Register* case report indicated evidence of either PM or RM.

Data on the prominence of scientific misconduct in the news media were obtained from the *Access World News* database on 15 Jun 2012 using a query of 5 two-word phrases: ("scienc* fraud" or "scienti* fraud" or "research fraud" or "scien* misconduct" or "research integrity"). Many broader queries, such as (research and fraud), were not included because they retrieved large numbers of articles referring to unrelated topics, such as "police misconduct" or "corporate fraud," while the phrase "data manipulation" was used in many articles related to the finance industry. The *Access World News* database groups query results by month allowing convenient generation of the monthly counts. For each of the observed monthly peaks, the retrieved articles were surveyed; and when a majority of them (>50 %) were related to specific case(s) the researchers involved are indicated. In some very high profile cases, multiple developments led to a series of peaks. The peak on October 2003 corresponded to a criminal case in which an expert witness accused the police of forensic "scientific misconduct," and that phrase was repeated in dozens of articles.

The professional position of individuals found guilty of misconduct by the ORI were obtained from 192 "findings of scientific misconduct" cases published in *The Federal Register* as of 15 September 2011. These case descriptions are much more detailed than most retraction notices published in the journals; and most provide the academic position of the individual at the time the alleged misconduct occurred. They also include cases

where falsified information was provided on grant applications or RM which did not involve any published articles.

Data were analyzed by contingency table analysis, with Chi-squared test, to determine the significance of differences observed between retraction justification categories and professional positions of individuals implicated in misconduct cases published in *The Federal Register*.

Results and discussion

Rising number and proportion of articles retracted due to misconduct

The number of articles retracted each year among all scholarly fields, and those retracted due to any form of misconduct, increased linearly by ~2 % per year from 1980–2000, then exponentially thereafter (Fig. 1). While the percentage of all retracted articles which involve misconduct allegations fluctuates from year-to-year, it grew from 18.5–29.2 % for each year from 1990–1993 to 55.8–71.9 % for each year from 2007–2010, which is a statistically significant difference at $p < 0.05$. Thus, the increasing impact of misconduct on the published literature among articles indexed in PubMed (e.g., Steen 2011; Woolley et al. 2011) is also evident across all scholarly literature. We previously noted that two main contributors to these increases are the growing numbers of both prolific "repeat offenders" and articles withdrawn while "in press" in recent years; with the overall growth of the published literature playing only a minor role (Grieneisen and Zhang 2012).

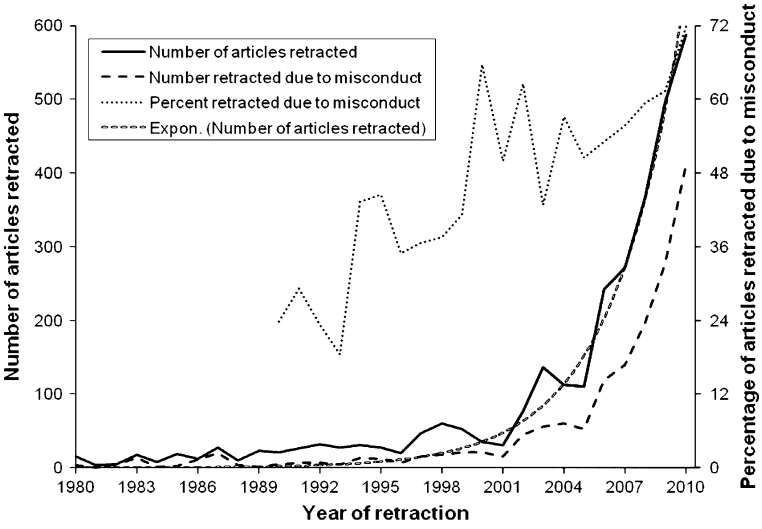

Fig. 1 Total articles retracted and those retracted due to misconduct for each year from 1980–2010. Prior to 1990, total retraction numbers per year were so small that percentages due to misconduct fluctuated between 0 and 100 % for individual years; and values range from 18.5 to 71.9 % of all articles retracted in each year from 1990–2010. The "Number of articles retracted" has increased exponentially from 2000–2010, as: $y = 26.395e^{0.2915x}$. *Note* The "Number of articles retracted" data (*solid line*) are the same as reported previously (Grieneisen and Zhang 2012)

Minimal impact of justification information from sources other than retraction notices and *The Federal Register.*

Retraction notices are often vague regarding the justification(s) for retraction. To supplement the justifications given in retraction notices, the data in our previous study (Grieneisen and Zhang 2012) incorporated information from the ORI cases published in *The Federal Register* and other widely-publicized fraud cases (e.g., the Slutsky case). However, a recent study on retracted articles in PubMed (Fang et al. 2012) went beyond these sources, incorporating additional information from the Retraction Watch blog and news media. They were able to reclassify the justifications for 158 retracted articles, and provided a list of them in supplementary information. We compared the classifications of those same articles in our survey to determine how many would be reclassified based on the additional information. Ten of the articles (Table S1) had been retracted after our database queries, so only 148 of the articles reclassified by Fang et al. (2012) were included in Grieneisen and Zhang (2012) and the current study.

The distributions of the 148 articles common to both studies among the categories of Fang et al. (2012) and Grieneisen and Zhang (2012) are shown in Table 1. The largest category shifts involved 23 articles which we had classified as "No reason given" (i.e., in the retraction notice) and 46 as "Distrust data or interpretations" reclassified as either "Fraud" or "Possible fraud". However, given the scope of the retracted literature, these shifts have only minimal impact on the overall percentages among all retracted articles (Table 2). As our previous study had already included the information from ORI cases, only minor increases in the percentages of articles retracted due to "Fraudulent/fabricated data" (16.6–18.4 %), "Questionable data or interpretations" (42.0–42.4 %) or "Research misconduct" (20.0–21.7 %) were noted when incorporating the other secondary sources used by Fang et al. (2012).

Table 1 Categories assigned to the 148 articles reclassified in Fang et al. (2012) which were included in Grieneisen and Zhang (2012)

Reclassification categories in Fang et al. (2012)	Categories of the same 148 articles in Grieneisen and Zhang (2012)
Fraud (135 articles)	Fraudulent/fabricated data (69)
	Other research misconduct[a] (3)
	Distrust data or interpretations (41)
	No reason given (22)
Possible fraud (6)	Distrust data or interpretations (5)
	No reason given (1)
Error (no IRB) (1)	Other research misconduct (1)
Duplicate publication (4)	No reason given (4)
Plagiarism (1)	Plagiarism (1)
Unknown (1)	Artifact[b] (1)

Ten of the 158 articles reclassified in Fang et al. (2012) were retracted after our database queries were conducted

[a] Based on text of retraction notice: "Discrepancies between raw and published data" or "violation of the ACS Ethical Guidelines"—These were counted as "misconduct" but not "Fraudulent/fabricated data" in Grieneisen and Zhang (2012)

[b] Based on text of retraction notice: "questions concerning the validity of data"

Table 2 Effect of reclassifications on numbers of retracted articles in each retraction justification category

Justification categories[a]	Original classifications[a,b]	With reclassification[c]
Primary categories		
1. Distrust data or interpretations	915 (25.2 %)	869 (23.7 %)
2. Fraudulent/fabricated data	602 (16.6 %)	674 (18.4 %)
3. Other research misconduct	123 (3.4 %)	120 (3.3 %)
4. Plagiarism	796 (21.9 %)	796 (21.8 %)
5. Duplicate publication	562 (15.5 %)	566 (15.5 %)
6. No reason given	601 (16.6 %)	574 (15.7 %)
Combined categories		
Questionable data or interpretations (mainly 1 and 2 above)	1,526 (42.0 %)	1,552 (42.4 %)
Research misconduct (2 and 3 above)	725 (20.0 %)	794 (21.7 %)
Publishing misconduct (4 and 5 above)	1,690 (46.5 %)	1,694 (46.3 %)

[a] Data and categories from Fig. 3 of Grieneisen and Zhang (2012)

[b] Percentages are based on 3,631 articles with justification information in the retraction notice or ORI cases published in *The Federal Register*

[c] Data incorporating reclassification categories of 148 articles listed in Table S1 of Fang et al. (2012) and included in this study. Percentages are based on 3,658 articles with justification information in either the retraction notice or any of the secondary sources cited in Fang et al. (2012)

Retraction rates and attributes differ between medical and non-medical literature

The characteristics of retracted articles vary among scholarly disciplines. According to contingency table analysis ($p < 0.0001$), a significantly higher percentage of non-PubMed (70 %) retractions were motivated by some form of misconduct than those in PubMed (60 %) (Table 3). However, publication misconduct was significantly more prominent among non-PubMed (56 %) than among PubMed (35 %) retractions; while PubMed retractions exhibited significantly higher proportions of the three categories which involve problems with data or interpretations as published (Table 3). Web of Science categories which overlap with medicine in Chemistry (*Chemistry, Medicinal* and *Biochemistry and Molecular Biology*, Table 4) and the Life Sciences (the molecular and cellular level subdisciplines, Table 5) have higher retraction rates per 100,000 articles than the other subdisciplines in those fields. Since most of the publications of the repeat offenders were in clinical medicine, the only subdiscipline in chemistry and the life sciences affected by them was *Crystallography*.

A recent study (Fang et al. 2012) found 43.4 % of 2,047 retracted articles from PubMed were retracted due to "Fraud", while another (Grieneisen and Zhang 2012) found only 20 % of 4,445 articles, only about half (1,891) of which were from PubMed, were retracted due to the roughly equivalent category of "Fraudulent/fabricated data". The data in Table 3 indicate that this difference in percentages was primarily due to the former study's (Fang et al. 2012) exclusion of the non-PubMed literature, which has a much larger proportion of retractions due to Publication misconduct.

Two factors believed to motivate intentional data manipulation are an increasingly "publish-or-perish" world coupled with the decreasing publishability of negative results (see Fanelli 2012, and citations therein). Fanelli (2012) found that the frequency of

Table 3 Differences between PubMed and "non-PubMed" retraction justifications among 3,631 articles for which retraction notices or ORI cases stated the justification

	Total	Any misconduct[a]	Publication misconduct[a]	Research misconduct[a,b]	Data fraud[a,b]	Distrust data or interpretations[a,b]
PubMed	1,663	1,001 (60 %)	589 (35 %)	436 (26 %)	367 (22 %)	984 (59 %)
Non-PubMed	1,968	1,374 (70 %)	1,100 (56 %)	288 (15 %)	237 (12 %)	541 (27 %)

Note that the PubMed literature has dramatically higher percentages retracted due to issues involving data integrity, while the non-PubMed literature has a higher proportion of "Publication misconduct" cases

[a] $p < 0.0001$, by contingency table analysis and Chi-squared test of PubMed versus non-PubMed data

[b] The three non-exclusive categories of Research misconduct, alleged data fraud, and Distrust data or interpretations include articles for which all or some of the data or interpretations are suspect

Table 4 Retractions per 100,000 web of science (WoS) records for 1980–2011 among sub-disciplines of chemistry

WoS categories in the field of chemistry	Retracted articles in category	WoS records for 1980–2011 (on 23 September 2011)	Retractions per 100,000 WoS records
Crystallography	136	184,948	74
Crystallography (minus repeat offenders)	64	184,948	35
Chemistry, medicinal	67	192,417	35
Biochemistry and molecular biology	419	1,597,361	26
Electrochemistry	18	145,883	12
Biochemical research methods	29	237,186	12
Chemistry, physical	89	766,563	12
Chemistry, organic	54	478,479	11
Chemistry, analytical	44	429,229	10
Polymer science	31	326,969	9
Chemistry, applied	20	221,241	9
Physics, atomic, molecular and chemical	31	369,624	8
Chemistry, multidisciplinary	95	1,208,172	8
Chemistry, inorganic and nuclear	22	304,329	7
Engineering, chemical	33	519,290	6

Note that retraction rates tend to be higher in the subdisciplines with greater overlap with medicine—*chemistry*, *Medicinal* and *Biochemistry and Molecular Biology*. The only chemistry sub-discipline with >1 retraction per 100,000 WoS records due to the repeat offenders (Grieneisen and Zhang 2012) is *Crystallography*

"positive results" among publications which declared to have tested a hypothesis was "significantly higher when moving from the physical to the biological to the social sciences, and in applied versus pure disciplines;" and that the strongest increases in percentages of positive results publications occurred in fields such as clinical medicine, pharmacology and toxicology and molecular biology. These same fields were found here to have the highest rates of retractions per 100,000 published articles, and those in PubMed were more likely to involve issues with reliability of data or interpretations.

Table 5 Retractions per 100,000 web of science (WoS) records for 1980–2011 among sub-disciplines of life sciences

WoS categories in the field of life sciences	Retracted articles in category	WoS records for 1980–2011 (on 23 September 2011)	Retractions per 100,000 WoS records
Developmental biology	63	123,605	51
Virology	39	147,474	26
Biochemistry and molecular biology	419	1,597,361	26
Cell biology	198	807,708	25
Biophysics	94	406,156	23
Biotechnology and applied microbiology	81	407,228	20
Materials science, biomaterials	8	43,176	19
Microbiology	65	403,373	16
Plant sciences	62	475,867	13
Biochemical research methods	29	237,186	12
Physiology	44	363,056	12
Reproductive biology	17	142,047	12
Parasitology	7	77,264	9
Entomology	13	143,899	9
Biology	41	454,240	9
Anatomy and morphology	5	59,614	8
Evolutionary biology	9	108,450	8
Biodiversity and conservation	4	51,070	8
Ecology	22	291,622	8
Mathematical and computational Biology	4	61,102	7
Behavioral sciences	9	141,484	6
Zoology	17	303,768	6
Microscopy	2	36,475	5
Mycology	2	41,228	5
Agriculture, dairy and animal sciences	8	166,920	5
Veterinary sciences	17	407,432	4
Marine and freshwater biology	7	205,982	3
Psychology, biological	1	64,484	2
Limnology	0	39,611	0
Ornithology	0	31,895	0

Note that rates are 12 per 100,000 articles or higher in subdisciplines with greater overlap with medicine (i.e., those at the molecular and cellular level); while the organismal and population level fields tend to have 10 or fewer retractions per 100,000 WoS records. The repeat offenders did not contribute >1 retraction per 100,000 WoS records for any of the life sciences sub-disciplines

These differences may reflect greater scrutiny of published data with implications for human health or the difficulty of performing "true replications" of studies involving human subjects.

Retraction rates differ greatly among 12 broad fields of scholarly literature

Among broad disciplines, medicine, chemistry and non-medical life sciences show substantially higher rates of overall retractions (Fig. 2, blue bars) and those motivated by misconduct allegations (red bars) or "distrust data or interpretations" (green bars) than other fields. The focus on research and publication misconduct in medicine (e.g., Steen 2011; Woolley et al. 2011) has been much more intensive than in chemistry despite their similar rates of misconduct retractions per 100,000 articles (Fig. 2, red bars). The articles from the repeat offenders are known to skew comparisons of retraction rates. Subtracting the articles from the repeat offenders decreases the retraction rate in medicine to 5.61 retractions per 100,000 articles, which is about 10 % less than the rate of 6.23 for chemistry (Fig. 2, purple bars).

The perception of misconduct's impact among researchers in these fields is very different from the occurrence rates in Fig. 2. For example, misconduct was perceived to be a "major problem" among surveyed "senior scientists in Germany" in clinical research (80 %), but not those in chemistry (4 %) (Abbott and Graf 2003). This "perception gap" may be due to the higher number of articles retracted due to misconduct, and those from the repeat offenders, in medicine (954 and 247, respectively) than chemistry (479 and 91). The fact that repeat offender cases emerged in medicine in the 1980s (Grieneisen and Zhang 2012), decades before their occurrence in other fields, may also have contributed to a heightened awareness of the impacts of misconduct among medical researchers today. However, the data presented here suggest that researchers in all fields must remain vigilant in providing mentoring and oversight of the research and publishing efforts in their labs, and scrutinizing the outside manuscripts they edit, in order to minimize the occurrence of misconduct.

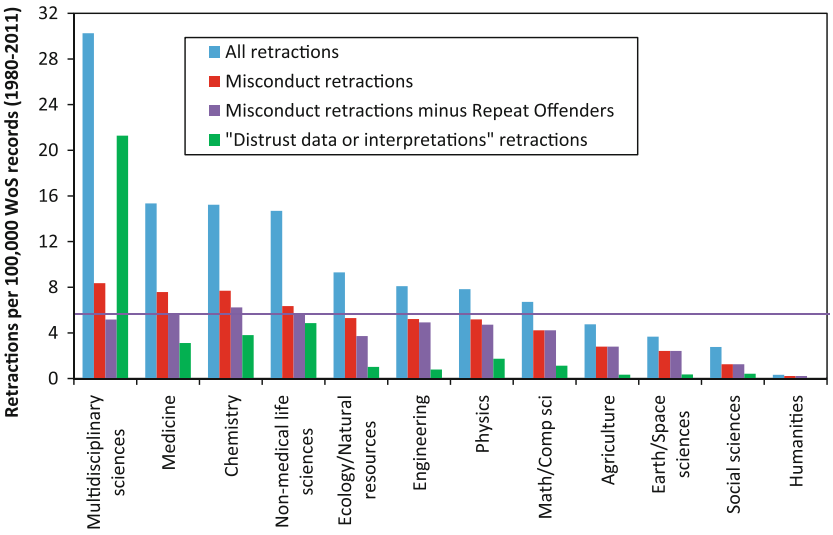

Fig. 2 Retraction rates for major disciplines from 1980–2011 adjusted for the number of publications in each field in web of science (WoS). "Misconduct retractions" includes all cases of either research or publication misconduct, while "Distrust data or interpretations" includes cases of experimental artifacts and data irreproducibility, in addition to a smaller number of suspected data manipulation cases. The *purple horizontal line* shows the level of misconduct retractions minus repeat offenders in medicine

Rising retraction rates have not increased media attention on research integrity

We also examined whether the recent dramatic rise in scholarly article retractions due to misconduct has translated into increased media attention on this issue, which would be expected to influence public opinion regarding research integrity. Editorials often mention "erosion of public trust" as a damaging outcome of RM cases (e.g., Godlee and Wager 2012); though "public trust in science" among individuals may be strongly influenced by opinions regarding science as either a driver of technological innovation or a hinderance of innovation and economic growth by fueling governmental regulation (Gauchat 2012). Considering the dependence of scientific and medical research on public funding, the paucity of comprehensive studies on media coverage of scholarly article retractions and misconduct is surprising (Greenbaum 2009; Rada 2005, 2007). If "newsworthiness" relates to public sentiment, then the prominence of RM in the news media may be a good proxy for public perception. A query of *Access World News* (AWN) database reveals spikes in the number of articles on RM which have coincided with specific misconduct cases since the late 1970s (Fig. 3). Surprisingly, however, no increase is apparent in either the frequency of these spikes or the baseline level between spikes since the 1980 s. Most of the news articles since November 2009 involved just two individual misconduct cases (Fig. 3, red shaded area), and even the most dramatic "repeat offender" cases often receive only minimal attention. For example, a query of AWN for "Joachim Boldt," the anesthesiologist with 88 retracted clinical studies (Tramer 2011), yielded only 11 articles; while the cloning scandal of Hwang Woo Suk (Fig. 3, peak 14) involved just two retracted articles but yielded hundreds of news stories. Thus, "newsworthiness" seems dependent upon specific aspects of individual cases, such as the field—with "cloning" (peak 14) and "climate change" (peak 16) being far more newsworthy than "anesthesiology". It is also noteworthy that while only half of the AWN sources are from North America, peaks 1–13 all involved researchers in the USA.

Retraction rates and attributes differ among author affiliation countries

The literature retracted due to research and publication misconduct includes worldwide author affiliations, involving 39 and 79 countries, respectively. Figures for the top RM affiliations—USA (367 articles), EU-27 (198), Germany (143), and China (126) (Table 6)—are all heavily influenced by a few individual "repeat offenders" (Grieneisen and Zhang 2012). The top publication misconduct affiliations were China (424 articles), EU-27 (322), USA (276) and India (193) (Table 6), and the only repeat offender contribution to this category involved 19 articles from India. The category "distrust data or interpretations" is dominated by experimental artifacts and unexplained data irreproducibility, with a lesser contribution from cases of alleged data manipulation. Thus, it is noteworthy that Iran (6.60), India (5.68), Turkey (5.38), South Korea (3.59), and China (2.00) have dramatically higher ratios of "publication misconduct" to "distrust data or interpretations" than those for other countries (Table 6). India is the only one of these five countries where English is the official language. Because plagiarism is a major component of the PM category, these data suggest that the English language barrier may be at least partially responsible for the high ratios of Iran, Turkey, South Korea and China. Increasing requirements for English language proficiency among science and technology students, and providing institutional support in non-English-speaking countries for English-language translation of research manuscripts prior to submission, may temper the temptation of authors in these regions to plagiarize English text.

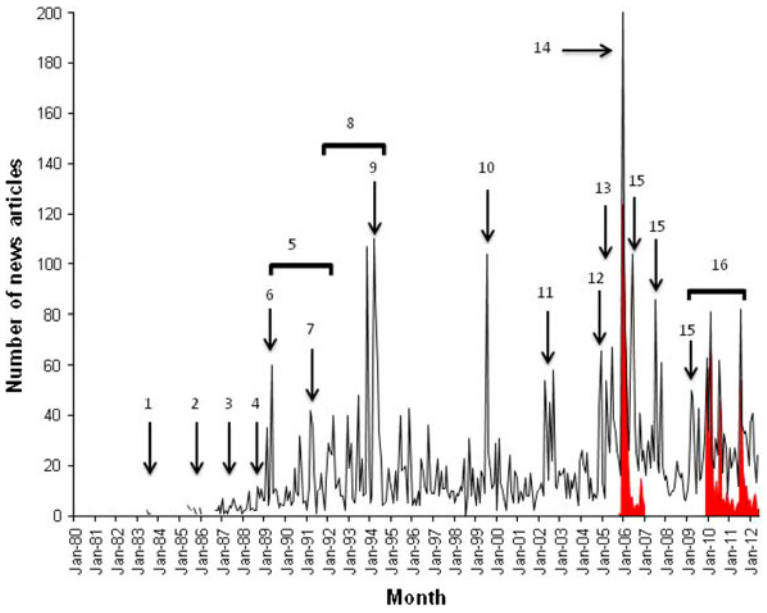

Fig. 3 Monthly counts of articles on scientific misconduct in the *Access World News* database. *Numbered peaks* represent one or a few specific cases dominating the articles for the months indicated: *1* John Darsee; *2* Robert Slutsky; *3* Charles Glueck; *4* Stephen Breuning; *5* David Baltimore/Thereza Imanishi-Kari; *6* White House climate change report; *7* Peak for Baltimore/Imanishi-Kari; *8* Robert Gallo; *9* Bernard Fisher; *10* Robert Liburdy; *11* Bruce Hall, Victor Ninov and Jan Hendrik (3 separate cases); *12* David Graham and Edmund Tramont (2 separate cases); *13* Ward Churchill and Misconduct survey of Univ. Minnesota; *14* Hwang Woo Suk, Merck/Vioxx case, and Eric Poehlman (3 separate cases); *15* Ward Churchill (3 separate developments); *16* Univ. East Anglia "climategate". The number of articles on Hwang Woo Suk (10/2005–12/2006) and "climategate" (11/2009–05/2012) are indicated in *red*

The differences in misconduct rates between countries may have cultural influences. Scientists worldwide are measured by their publication of high-profile scientific papers. Under the strong pressure of academic "publish or perish", searching for an "easy" way to generate high impact factor papers or large numbers of papers may motivate a few desperate scientists to fabricate results or copy others in their writings. From our personal experiences interacting with visiting scholars from China, India, Turkey and South Korea, copying a paragraph or so from published papers or textbooks for writing a term paper or manuscript is often viewed as a routine and acceptable practice. A recent article discusses this factor in Iranian scientific culture (Ghazinoory et al. 2011). The higher misconduct rates also seem to occur in countries which have experienced exponential growth in scientific publication output in recent years (e.g., Ghazinoory et al. 2011; Fu et al. 2011; Mahbuba and Rousseau 2012; Sotudeh 2012) and their publication misconduct rates may decline to the levels of other non-English speaking countries with the maturation of their now rapidly expanding research cultures. Revealing the geographic distribution of this form of misconduct, and emphasizing its seriousness, will increase awareness and understanding of these issues within the global research community.

Are junior researchers more likely to commit research misconduct?

Many editorials emphasize the need to train early career researchers on proper codes of research (and publishing) conduct, whether through courses or simply good mentorship

Table 6 Retractions motivated by misconduct and distrust data or interpretations for all countries with more than 50 total retractions, the UK and EU-27

Country or region[a]	Research misconduct (RM)	Publication misconduct (PM)	Distrust data or interpretations (DDI)	Percentage of all country retractions		Ratio PM/DDI
				% PM	% DDI	
Iran	1	66	10	74	11	6.60
India	15	193	34	76	13	5.68
Turkey	1	43	8	61	11	5.38
South Korea	9	97	27	49	14	3.59
China	126	424	212	56	28	2.00
Italy	11	39	29	43	32	1.34
EU-27	198	322	329	34	35	0.98
France	15	38	39	36	37	0.97
UK	30	84	99	33	39	0.85
England	27	70	83	33	39	0.84
Japan	48	89	115	36	46	0.77
Canada	8	35	50	31	44	0.70
Australia	4	20	31	28	44	0.65
Germany	143	71	119	23	38	0.60
Switzerland	19	9	24	18	48	0.38
USA	367	276	785	22	62	0.35
Total	1,022	1,876	1,994			

"Publication misconduct" is dominated by plagiarism and duplicate publications, while "Distrust data or interpretations" is dominated by unexplained irreproducibility and experimental artifacts

[a] Data are presented for all countries with more than 50 total retractions, the UK and EU-27, since they have greatest impact on the scholarly literature

(Kornfeld 2012). But what proportion of misconduct cases are likely attributable to the naïveté of junior researchers and support staff? Among 183 cases of positive "findings of research misconduct" by the U.S. ORI which stated the position(s) held while committing misconduct, the cases involving researchers in junior positions ($n = 135$, 73 %) outnumbered those involving senior positions ($n = 51$, 28 %) by a factor of 2.6 (Table 7). While this data indicates junior researchers are responsible for a majority of misconduct cases, it may partially reflect the fact that junior researchers (graduate students and postdocs) often outnumber senior personnel in many research settings. Furthermore, junior researchers are often more directly involved in the hands-on generation of data and writing of manuscripts. Personal consequences of research and publication misconduct can be very detrimental to either junior or senior researchers. In addition to the public embarrassment, misconduct may lead to publications spanning an entire career being scrutinized and/or retracted (Rasmussen et al. 2012), loss of job or tenure and difficulty finding future employment, a ban on applying for funding or publishing in specific journals, or even withdrawal of a granted doctoral degree (Lieb 2004). One case involved a fine up to $250,000 and up to 5 years in prison (Kintisch 2005), though the actual punishment was less severe (Tilden 2010). However, punishment is only a deterrent when the consequences are widely known; and we could not find any published studies on the level of awareness among researchers of these potentially severe consequences. The ethics training programs

Table 7 Characteristics of 192 academic misconduct cases listed in *The Federal Register* as of 30 September 2011

80 (42 %) involved publications (excluding manuscripts withdrawn prior to publication and dissertations); therefore, 112 (58 %) did not involve publications
These 80 cases yielded 182 journal articles and 4 book chapters
Fates of the 182 journal articles: 140 (77 %) retracted, 24 (13 %) errata, 17 (9 %) no notice (as of 30 September 2011), 1 (1 %) republished in corrected form
68 (35 %) involved misrepresentation of data or credentials on grant applications
72 (38 %) involved research activities other than published works or grant applications
73 (38 %) involved human subjects; 109 (57 %) did not; 10 (5 %) could not be determined from information provided
Professional positions at the time of misconduct. Because 9 (5 %) did not mention position of researcher at the time of misconduct, percentages are based on 183 informative cases. Sum exceeds 183 because a few individuals had committed misconduct in more than one position.
Senior research positions (51, 27 %):
Instructor-1
PI-2
Professors (41):
Assistant Professor-13
Associate Professor/adjunct associate Professor-17
Full Professor-11
Research fellow/research Scientist/researcher-5
Senior scientist-1
Visiting fellow-1
Junior research positions and support staff (135, 73 %):
Assistant/assistant research Scientist/research assistant-13
Clinical coordinator-3
Clinical research associate/research associate-7
Contract employee/employee/staff-14
Counselor/interviewer/study counselor-4
Data coordinator/data manager-3
Executive manager for corporate planning-1
Graduate student/medical student/resident-35
Phlebotomist-2
Postdoc-36
Project director/research coordinator/research program (or Project) coordinator-6
Technician-9
Undergraduate assistant-2

that are becoming more widely adopted by academic institutions (Stanbrook et al. 2011) should include facts about the potential career-related consequences of misconduct.

Impacts of research misconduct extend beyond the published literature

Professional misconduct among researchers often involves activities other than conducting research and publishing the findings. In fact, 56 % of ORI's "findings of scientific misconduct" cases involved no publications, and 35 % involved misrepresentation of

preliminary data or credentials on grant applications (Table 7). These figures underscore the importance of studying aspects of misconduct by researchers which do not involve the published literature, many of which have been largely ignored in non-medical fields. For example, the 18 studies on publication misrepresentation by medical residency and fellowship applicants (Wiggins 2010) stand in contrast to the complete lack of similar studies among post-doctoral applicants. Further studies characterizing various forms of professional misconduct outside of medicine would clarify whether they are more prevalent in medicine than other scholarly fields, and reveal the impacts of all forms of professional misconduct on science as a whole.

Conclusions

The introduction of the *Singapore Statement on Research Integrity* in 2010 (Resnik and Shamoo 2011) provided the first globally recognized set of guidelines on the responsible conduct of research. Editorials in scholarly journals offer many conflicting opinions on how to most effectively improve the level of research integrity. The results of this comprehensive survey of articles retracted due to misconduct suggest four trends that all stakeholders in scholarly research should bear in mind:

- Chemistry and the non-medical life sciences have misconduct-motivated retraction rates similar to medicine, when the figures are adjusted for the size of the published literature and the "repeat offender" articles are discarded as outliers. These similarities are in stark contrast to the perceived extent of misconduct by researchers in various fields.
- To reduce the temptation of English language plagiarism by authors for whom English is not their first language, linguistic training and institutional support for English manuscript preparation should be made available to them.
- More than 1/3 of ORI's findings of misconduct cases involved misrepresentation of data in grant applications; and "padding" of credentials in fellowship applications by medical students is well-documented (Wiggins 2010). Since they may contain information that is manipulated for self-promotion, publication lists and preliminary data presented in applications for grants and professional positions should be subject to the same level of scrutiny as manuscripts under review.
- The prominence of research integrity in the news media has not increased along with rates of articles retracted due to misconduct; and most scientific misconduct cases, including the most severe repeat offender cases, never attract high-profile media coverage.

Acknowledgments Authors wish to thank the reviewers and the editor for their review of the manuscript and provided the constructive comments. We would like to thank the people in the AGIS laboratory at University of California Davis for the discussion at earlier stage of the manuscript. We also wish to acknowledge Wenzhou Medical College and Wenzhou City (No. 89207011, 20082780125) and Science and Technology Department of Zhejiang Province (No. 2008C03009) China for partial financial support for this project.

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