

# An Analysis of Retracted Articles with Authors or Co-authors from the African Region: Possible Implications for Training and Awareness Raising

Theresa M. Rossouw<sup>1,\*</sup>, Liapeng Matsau<sup>2</sup>, Christa van Zyl<sup>3</sup>

<sup>1</sup>University of Pretoria, Pretoria, South Africa

<sup>2</sup>South African Qualifications Authority, Pretoria, South Africa

<sup>3</sup>Human Sciences Research Council, Pretoria, South Africa

\*Corresponding Author: Theresa M. Rossouw, Department of Immunology, Room 5-46, Level 5, Institute for Pathology, University of Pretoria, Private Bag X20, Hatfield 0028, South Africa. Email: [theresa.rossouw@up.ac.za](mailto:theresa.rossouw@up.ac.za)

## Abstract

Retraction of research articles is increasing but the reasons and characteristics of retractions involving authors from Africa have not been studied. Using records from the *Retraction Watch* database, we analyzed information on articles retracted between 2014 and 2018 with at least one author or co-author affiliated with an institution in the African region to determine the most prevalent types of misconduct, subject fields, and the characteristics of researchers or research teams associated with retraction. Plagiarism was the most frequent form of misconduct, followed by duplication. International collaboration was associated with fewer retractions for plagiarism and errors in data, but increased retractions due to authorship issues. Teams with at least one senior member were associated with fewer retractions due to plagiarism but more due to duplication of articles. We conclude by making recommendations for best practice, further research, and highlighting implications for education.

**Keywords:** retractions, Africa, plagiarism, duplication, research integrity, ethics training

## Introduction

Retraction of research articles has been on the rise in recent years, increasing at higher rates than the associated growth in research output (Damineni et al., 2015; Grieneisen & Zhang, 2012; He, 2013; Karabag & Berggren, 2016; Resnik et al., 2015; Shuai et al., 2017). Even though the number of retractions relative to what had been published globally remains very small, this phenomenon warrants further attention. The very act of retraction—a withdrawal of an earlier statement or publication, or, in the context of this study, “a notification by a journal that an earlier publication in that same journal has been declared invalid” (Schmidt, 2018)—points to a system with checks and balances in place. Many authors emphasize that corrections or voluntary retractions should be seen as evidence of the self-correcting virtue of the scientific enterprise, with the recent growth in retractions serving as indicator of increased levels of awareness, better methods or software applications to detect problems, and a stronger culture of accountability and transparency in the scientific community (Fanelli, 2013; Hosseini et al., 2018; Van Noorden,

2011; Wager & Williams, 2011). Reports on articles retracted by Nobel laureates serve as cases in point (Blanchard, 2020; Katsnelson, 2010). However, articles that are retracted may also point to inefficiencies and wastage in the scientific enterprise, bearing in mind that time, resources and publication space had been allocated to outputs that should not have been published. Most concerning, however, are retractions resulting from scientific misconduct or other questionable research practices, which are indeed hurting the system. In this regard, the credibility and integrity of journals, journal editors and the peer review system might be questioned.

As pointed out by Stern et al. (2014), articles that are retracted due to misconduct have serious financial implications—not only because of the apparent wastage of grant funds on fraudulent research, but also because of scarce resources that have to be spent on investigations, administrative and legal fees, and on the costs associated with failed research done by others who tried to build on what turned out to be false. Moreover, fake and false findings can lead to incorrect conclusions, interventions that are harmful, and are difficult to undo once the results have found their way into public discourse. Examples of such cases include the now discredited breast cancer research by Werner Bezwoda (Ana et al., 2013; Lerner, 2009) and the fraudulent findings published by Andrew Wakefield and collaborators who claimed that measles, mumps, and rubella (MMR) vaccines may lead to autism (Chen et al., 2013; Rao and Andrade, 2011). In short, apart from negative implications for the reputation of individual researchers and institutions, retractions, especially those associated with research misconduct, can also bring damage to the scientific enterprise and the credibility of science as a whole (Nussenzveig and Zukanovich Funchal, 2008; Trikalinos et al., 2008). It is thus important to understand the reasons for retractions in order to mitigate these.

While the prevalence and possible root causes of retractions have been studied elsewhere (Fanelli et al., 2019; He, 2013), this has not been done for the African continent. Bearing in mind that authors and co-authors associated with African institutions often work in resource-poor settings where production of scientific outputs does not come easily (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2015), the negative impact of retractions in terms of apparent wasteful application of limited resources, as well as damage to reputations and reduced prospects for future funding or collaborative research, is a risk that should be better understood and mitigated where possible.

Little is known about the extent of research misconduct in Africa. There are no shared reporting systems, and generalizations tend to be based on well-known cases that are not representative of research in Africa as a whole (Kombe et al., 2014). While retractions should not necessarily be equated with misconduct, they are still a good proxy indicator, and point to the areas of misconduct or questionable research practices that are possibly more prevalent and in need of corrective or preventative action including training or awareness raising. Van Zyl et al. (2019), in an attempt to present objective information about the relative prevalence and kinds of research misconduct or questionable research practices in Africa, reviewed records of retracted articles involving authors from African countries contained in the on-line database of *Retraction Watch* (<http://retractiondatabase.org>). Compared with a reported 2.6% of global research output in 2014 (UNESCO, 2015), the relative proportion of retracted articles involving authors from

Africa was higher than the global average for the year 2014 in isolation, but lower for the articles in the entire database up to January 2018. Given limited data and fluctuations over time, the authors concluded that the aggregated data “conceal interesting trends and peaks, warranting more detailed analysis and discussion elsewhere” (Van Zyl et al., 2019, p. 150). This study attempted to further explore some of the trends, but not with the purpose of comparing authors from Africa or African countries with their global counterparts. Rather, the intention was to use records of retracted articles with authors or co-authors from Africa to obtain more information about reasons for retractions and characteristics of the authors or teams of authors involved, and to look for associations between variables from which findings and recommendations to support improved research and publication practice could be drawn.

The following research questions guided our further review and analysis of records obtained from the *Retraction Watch* database:

- What are the most prevalent types of research misconduct, as presented in reasons cited for the retraction of articles involving authors from Africa?
- Are there specific areas of research, or characteristics of researchers or research teams (e.g., in terms of relative seniority or gender) which appear more frequently in the *Retraction Watch* database?
- Which areas or issues should be prioritized in research integrity training or awareness raising initiatives, to reduce the risk of misconduct, questionable research practices and retractions?

## Methods

The protocol for this study was approved by the University of Pretoria Faculty of Health Sciences Research Ethics Committee (Reference No.: 507/2019).

The *Retraction Watch* database (<http://retractiondatabase.org/RetractionSearch.aspx?>) was used as basis for the study. To our knowledge, Retraction Watch is the only database that is freely available and provides an intuitively searchable database.

Records were selected by using search and filter functions in the database, as follows:

- Articles with a retraction notice dated from 1 January 2014 to 31 December 2018.
- “Retraction” as notice (i.e., “expression of concern” and “correction” were excluded).
- African country: Country names appearing in the drop-down menu of the database were compared with the names of 55 African countries recognized by the African Union (see <https://au.int/memberstates>).

Records were retrieved from the database over a period of 4 weeks, from 28 January to 25 February 2019. An extended period of cleaning, checking, and expansion of the selected records followed, especially to obtain more information on gender and seniority of authors listed in these records. This continued until May 2019. Records were extracted per country, yielding a total of 271 records. These included the expected duplicated entries of retracted

articles associated with co-authors from more than one African country. Records were captured in Excel spreadsheets, further expanded to include the number of retractions appearing in the database; author affiliation; author seniority and gender by searching online sites such as institutional websites and *ResearchGate*. Authors could have been from any ethnic, racial or cultural grouping; the only criterion for inclusion was that one of their institutional affiliations, as listed in the article itself, was in Africa. Authors were restricted to the first nine in order of appearance, as well as the last author. We used 13 meaningful labels to combine the almost 100 reasons appearing in the *Retraction Watch* database, similar to the categories created by Grieneisen and Zhang (2012), Damineni et al. (2015), Wager and Williams (2011) and Lei and Zhang (2018). Duplicate entries were identified and removed. Records were further checked and cleaned and were coded for purposes of further analysis. Where the same article had been extracted for more than one country, the record for the country of only the first-mentioned author with African affiliation was retained. Two records were removed due to errors in the database.

A total of 245 records were used for initial data analysis. The study dataset was analyzed with Stata 14, using basic descriptive statistics including means, standard deviations, proportions and percentages. Tests of association were performed by means of the student's *t*-test or Kruskal-Wallis for continuous variables and, for categorical variables, Pearson's chi-square or Fisher's exact test; the latter in case of low expected frequencies. In a small number of cases, the same authors were involved in multiple retractions. Although similar studies removed these from their samples (Fanelli et al., 2015; Shuai et al., 2017), we found, after doing similar analyses for a slightly smaller subset of 233 articles where unique authors (sole authors, or same teams of authors) with multiple retractions had been removed, that this made little difference to the findings of this study. As a result, the findings of the original number of 245 records are presented below.

**Table 1.** African Countries Associated with Authors of Retracted Articles.

Country (as named in the Retraction Watch database)	Number of articles (N = 245)	Percentage of 245
Algeria	28	11.43%
Cameroon	4	1.63%
Central African Republic	2	0.82%
Egypt	90	36.73%
Ethiopia	5	2.04%
Ghana	4	1.63%
Kenya	6	2.45%
Libya	2	0.82%
Mauritius	1	0.41%
Morocco	5	2.04%
Nigeria	29	11.84%
Republic of the Congo	2	0.82%
Senegal	1	0.41%
South Africa	37	15.10%
Sudan	1	0.41%
Tunisia	27	11.10%
Uganda	1	0.41%
Total	245	100%

**Table 2.** African Countries According to Number of Citable Outputs Produced, 2014 to 2018.

Country	2014	2015	2016	2017	2018	Total	% of African output
Algeria	5135	5769	6526	7032	6960	31422	7.5%
Angola	98	93	109	146	102	548	0.1%
Benin	399	423	400	478	495	2195	0.5%
Botswana	418	375	554	540	613	2500	0.6%
Burkina Faso	453	539	524	535	566	2617	0.6%
Burundi	42	48	51	54	78	273	0.1%
Cameroon	1113	1161	1272	1451	1601	6598	1.6%
Cape Verde	33	35	33	47	36	184	0.0%
Central African Republic	48	41	72	53	64	278	0.1%
Chad	31	37	44	56	53	221	0.1%
Comoros	6	8	17	12	18	61	0.0%
Congo	437	417	419	402	437	2112	0.5%
Côte d'Ivoire	356	401	383	402	507	2049	0.5%
Democratic Republic of the Congo	33	79	88	141	155	496	0.1%
Djibouti	24	17	19	21	21	102	0.0%
Egypt	15039	16099	18332	17702	20074	87246	20.8%
Equatorial Guinea	14	18	26	13	19	90	0.0%
Eritrea	29	29	26	36	46	166	0.0%
Ethiopia	1807	1816	2039	2739	3223	11624	2.8%
Gabon	184	183	175	179	182	903	0.2%
Gambia	157	165	164	178	142	806	0.2%
Ghana	1376	1607	1994	2176	2624	9777	2.3%
Guinea	62	98	115	124	87	486	0.1%
Guinea-Bissau	57	35	51	55	49	247	0.1%
Kenya	2255	2306	2489	2723	2840	12613	3.0%
Lesotho	34	44	49	46	47	220	0.1%
Liberia	31	59	79	84	83	336	0.1%
Libya	476	428	372	430	443	2149	0.5%
Madagascar	277	301	283	331	331	1523	0.4%
Malawi	477	516	575	679	709	2956	0.7%
Mali	204	258	251	288	269	1270	0.3%
Mauritania	40	37	54	46	61	238	0.1%
Mauritius	211	213	274	301	283	1282	0.3%
Morocco	4434	4532	5673	6460	6385	27484	6.6%
Mozambique	241	317	344	407	425	1734	0.4%
Namibia	246	285	311	314	386	1542	0.4%
Niger	134	174	165	148	155	776	0.2%
Nigeria	5823	5626	6423	6877	8346	33095	7.9%
Rwanda	248	299	337	357	433	1674	0.4%
Sao Tome and Principe	4	3	2	8	5	22	0.0%
Senegal	643	714	713	764	776	3610	0.9%
Seychelles	43	60	46	56	43	248	0.1%
Sierra Leone	68	105	137	136	136	582	0.1%
Somalia	16	17	13	34	28	108	0.0%
South Africa	18620	18481	20353	21421	21843	100718	24.0%
Sudan	644	647	831	784	921	3827	0.9%
Swaziland	106	110	100	130	133	579	0.1%
Tanzania	1261	1294	1347	1460	1526	6888	1.6%
Togo	156	161	160	143	178	798	0.2%
Tunisia	6317	6923	7651	8166	7790	36847	8.8%
Uganda	1209	1351	1402	1581	1601	7144	1.7%
Zambia	403	429	515	576	550	2473	0.6%
Zimbabwe	610	566	689	756	788	3409	0.8%
TOTAL	72582	75749	85071	90078	95666	419146	100.0%

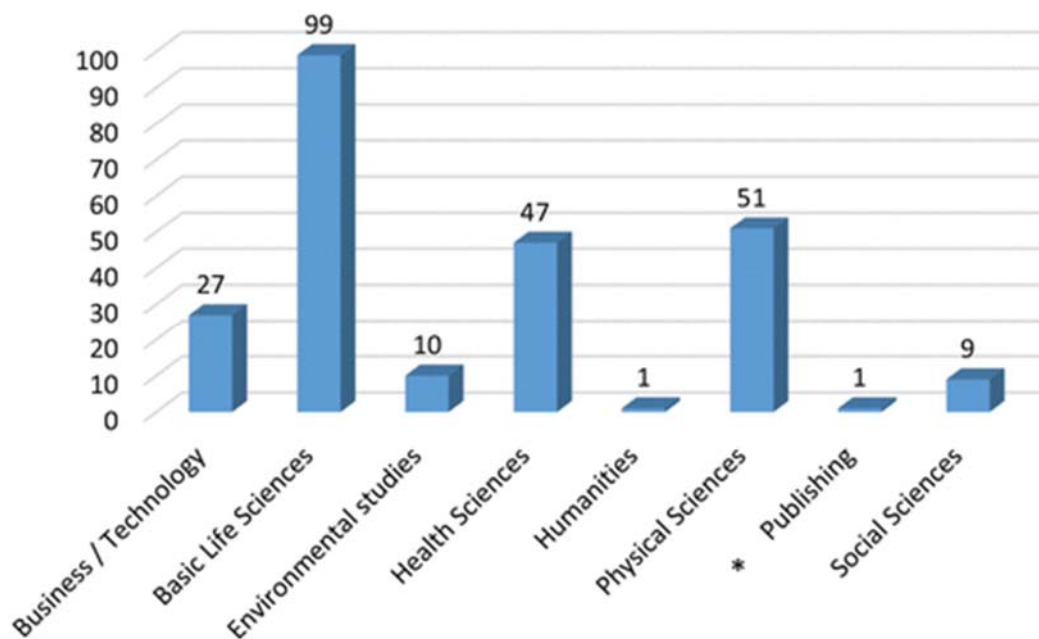
Note. Extracted and adapted from: SCImago Journal & Country Rank, <https://www.scimagojr.com/>.

## Results

Using the 245 records selected for analysis, 17 African countries appeared as country of institutional affiliation for the first author (Table 1). Of these, five countries contributed to the bulk (86.12%) of retracted articles, with Egypt contributing 90 (36.73%) of the articles, South Africa 37 (15.10%), Nigeria 29 (11.84%), Algeria 28 (11.43%), and Tunisia 27 (11.02%).

It should be noted that these five countries are also top contributors in terms of scientific output for the continent: Data extracted from the *SCImago* journal and country rank database (<https://www.scimagojr.com>) reveal that 69% of citable outputs from Africa that were published (i.e., not retracted) in the 5-year period from 2014 to 2018, had authors from these five countries (Table 2).

Figure 1 shows that each of the eight main subject fields used to categorize articles in the *Retraction Watch* database appeared at least once among the 245 retracted articles, as follows: Business/Technology for 27 (11.02%), Basic Life Sciences for 99 (40.41%), Environmental Studies for 10 (4.08%), Health Sciences for 47 (19.18%), Physical Sciences for 51 (20.82%), Social Sciences for 9 (3.67%), followed by Humanities and Publishing<sup>1</sup> each accounting for only one, or 0.41% of the 245 retracted articles. The vast majority (224, or 91.4%) of retracted articles were associated with only four of the eight subject fields, namely Business/Technology, Basic Life Sciences, Health Sciences, and Physical Sciences. Articles in the two fields associated with Biomedical and Health Sciences thus contributed almost 60% (146, or 59.60%) of all retracted articles.

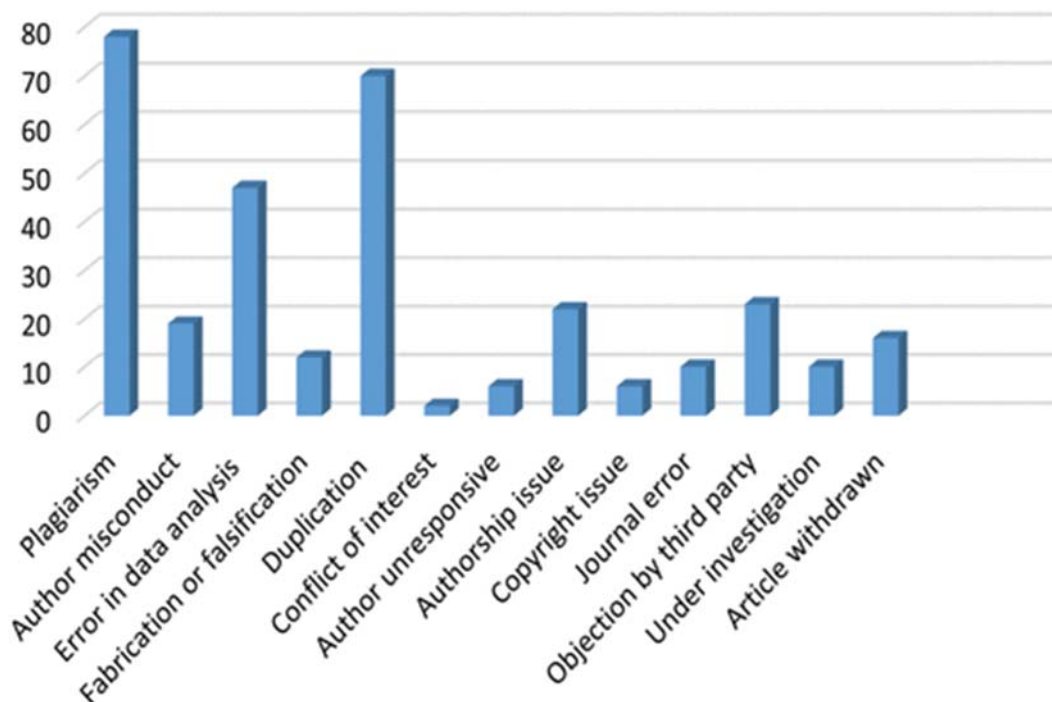


**Figure 1.** Main subject fields associated with retracted articles.

\*The Publishing category was not a completed category and has subsequently been removed from the *Retraction Watch* database.

The majority of articles (205, 83.67%) were co-authored and the median number of authors per article was three (interquartile range 2–5). In the majority of cases (145, 59.18%) all the authors were from one African country, followed by one African country with one or more non-African country (85, 34.69%), while collaboration between African countries, and between more than one African country and one or more non-African country occurred less frequently (9 [3.67%] and 6 [2.45%] respectively). Of the 13 reasons for retraction that had been captured, those mentioned most often were plagiarism (78, 31.84%), duplication (70,

28.57%), and error in data, analysis or conclusions (47, 19.18%) (Figure 2). It should be noted that more than one reason could have been cited for the retraction of individual articles. The mean period between publication and retraction was 761.02 days (SD 893.49) with a range between 0 and 5551 days (~15.2 years).



**Figure 2.** Reasons for retraction.

Almost three-quarters (134/182 [73.63%]) of the articles where seniority of authors could be established included at least one senior academic with the title of professor or equivalent among the authors. In the case of articles for which gender could be established (99.59% of first authors and 80.3% of all authors), the majority of first authors (177/244 [72.54%]) and authors overall (507/685 [74.01%]) were male. We subsequently tested for associations between different variables. For those entries with the gender of the first author available, we found an association between the gender of the first author and whether the retracted article had been single- or co-authored. Female first authors were more likely than their male counterparts to have involved co-authors (63/67 [94.03%] vs. 141/177 [79.66%];  $p = .006$ ). No further significant associations were found: gender and seniority of the team ( $p = .131$ ), the period of time between date of publication and retraction ( $p = .0886$ ), number of countries involved ( $p = .438$ ), the subject field of the retracted article ( $p = .432$  for all articles, and  $p = .386$  for the articles limited to the top four subject fields of Business/Technology, Basic Life Sciences, Health Sciences, and Physical Sciences), plagiarism ( $p = .898$ ), author misconduct ( $p = .603$ ), error in data, analysis or conclusion ( $p = .071$ ), fabrication or falsification ( $p = .188$ ), duplication ( $p = .635$ ), conflict of interest ( $p = .999$ ), author unresponsive ( $p = .327$ ), authorship issues ( $p = .325$ ), copyright issues ( $p = .999$ ) or journal error ( $p = .469$ ).

The next variable considered in relation to reasons for retraction was the number of countries represented among authors of retracted articles. For this purpose, we distinguished between authors from one country and authors from more than one country. There was a significant association between number of countries and plagiarism ( $p = .014$ ), with articles by authors from a single African country (55/145 [37.93%]) more likely to be retracted because of plagiarism, than articles with multi-country authors (23/100 [23%]).

When exploring associations between reasons for retractions and specific African countries, we limited our analysis to the five African countries with the most retracted articles. Fabrication or falsification was listed as the reason for retraction for only ten of the articles. The association between fabrication or falsification and specific African countries approached significance ( $p = .050$ ), with this reason mentioned for five articles from each of only two of the countries under consideration, namely Egypt (5/90 [5.56%]) and South Africa (5/37 [13.51%]).

Associations between reasons for retraction and types of collaboration were subsequently considered, with distinctions drawn between authors of retracted articles coming from only one African country, more than one African country, one African country plus one or more non-African country, and more than one African country with one or more non-African country. Significant associations were found in the cases of two reasons, but reported numbers were low overall. The first reason was error in data, analysis or conclusion, which had been listed for 47 out of 245 (19.18%) of all retracted articles, with articles authored by teams from more than one African country (at 4 out of 9, or 44.44%) apparently more likely to be associated with this problem ( $p = .044$ ). The second was authorship issues, which had been listed for 22 out of 245 (8.98%) of retracted articles, but appeared to have been more prevalent at 3/6 or 50% of the cases when authors from Africa collaborated with authors from outside Africa ( $p = .011$ ).

We subsequently limited our review of types of collaboration to two consolidated variables, namely authors from within Africa only and at least one author from outside Africa, to see if there were stronger associations emerging. Plagiarism, listed as reason for retraction in the case of 78 out of 245 (31.84%) articles, was significant with 57/154 (37.01%) cases for authors from within Africa only and 21/91 (23.08%) for authors from within as well as outside Africa ( $p = .024$ ). A significant association with authorship issues was again evident with teams involving authors from Africa only, apparently less likely to experience problems than teams involving authors from within and outside Africa (9/154 [5.84%] vs. 13/91 [14.29%];  $p = .036$ ).

The next variable reviewed was the seniority of authors where we differentiated between records with at least one author at the level of professor or equivalent, and those without any author at this level of seniority. A significant association was found for plagiarism, which had been mentioned as reason for retraction in 29 out of 134 (21.64%) cases where a senior author was involved, and 23 out of 48 (47.92%) where no senior was involved ( $p = .001$ ). The association between duplication and seniority of authors was also significant, mentioned 45 out of 134 (33.58%) times if a senior author was involved versus 7 out of 48 (14.58%) if there was no senior author involvement ( $p = .012$ ). This is interesting, suggesting that the



involvement of senior authors might reduce the likelihood of plagiarism, but increase the likelihood of duplicated publications.

Whether a retracted article had been single- or co-authored was subsequently considered in relation to reasons for retraction. There were two reasons for retraction where a significant association was found. The first was plagiarism, where the reason was listed in the case of 23 out of 40 (57.5%) articles that had been single-authored, and 55 out of 205 (26.83%) of co-authored articles ( $p < .001$ ). The second was duplication, with the reason listed for 4 out of 40 (10%) of single-authored, and 66 out of 205 (32.20%) of co-authored articles ( $p = .004$ ).

The associations between different reasons for retraction and the subject fields in which the retracted articles had been published were subsequently explored. For plagiarism listed as reason for retraction, there was a significant association with subject field ( $p = .015$ ). Plagiarism was listed as reason for retraction per subject field as follows: 13/27 (48.15%) for Business/Technology, 23/99 (23.23%) for Basic Life Sciences; 5/10 (50%) for Environmental Studies; 13/47 (27.66%) for Health Sciences; 1/1 (100%) for Humanities, 17/51 (33.33%) for Physical Science; 0/1 (0%) for Publishing, and 6/9 (66.67%) for Social Sciences. Although the actual numbers are small, there does appear to be a pattern emerging with articles from Business/Technology, Environmental Studies, Humanities and Social Sciences more frequently associated with plagiarism than articles in the Natural and Health Sciences, that is, Basic Life Sciences, Health Sciences, Physical Science, and also the single article published in the field of Publishing. When looking for associations in the four study fields with the most retracted articles (Business/Technology, Basic Life Sciences, Health Sciences and Physical Sciences), the association with plagiarism was no longer significant ( $p = .084$ ), but the association with author misconduct became significant ( $p = .017$ ) with authors from the Health Sciences and Basic Life Sciences more likely to have articles retracted for this reason (6/47 [12.77%] and 12/99 [12.12%] respectively) than Business/Technology and Physical Sciences (1/27 [3.7%] and 0/51 [0%] respectively).

Finally, we reviewed the number of retractions associated with all authors in our study dataset, by considering the number of retractions recorded for each of them in the *Retraction Watch* database. The vast majority of authors (203, or 82.86% of first authors) had only one record of retraction—regardless of position of co-authorship—associated with their name. Two authors had 10 retractions each, the maximum number recorded, followed by four authors with four retractions each.

## Discussion

The purpose of this study was not to stigmatize any specific research or research groups, but rather to inform international comparisons and educational best practice interventions. The study yielded results that are comparable with those of similar research conducted in other parts of the world.

- In response to our first question, “*What are the most prevalent types of research misconduct, as presented in reasons cited for the retraction of articles involving authors from Africa?*,” we found the following:

Not all of the 13 reasons for retraction that were analyzed involved research misconduct or questionable research practices. A reason such as “journal error” (10 instances recorded) may point to weaknesses in the system, “article withdrawn” (16 instances) might signal virtuous conduct of authors who wanted to correct an honest error (Fanelli, 2013), whereas “under investigation” (10 instances) and “author unresponsive” (6 instances) typically refer to issues that have not yet been confirmed or resolved.

Of the three major forms of research misconduct (Office of Science and Technology Policy, 2000), plagiarism (79 instances) was much more prevalent than fabrication or falsification, with only 12 instances recorded. In fact, it appears that problems with publication ethics—notably plagiarism, as well as duplication of articles (70 instances) and authorship issues (22 instances)—can be regarded as an issue that warrants more attention on the African continent as well as globally (Damineni et al., 2015; Grieneisen and Zhang, 2012; Stavale et al., 2019; Wager and Williams, 2011). Plagiarism has been identified as an issue that tends to be more prevalent in low- and middle-income countries where lack of training and awareness, combined with limited resources, cultural factors, and language barriers have been listed as possible reasons (Ana et al., 2013; Hesselmann et al., 2017; Rohwer et al., 2017; Stretton et al., 2012). Within the African continent, various initiatives at country level point to an acknowledged need to deal with this issue: In Algeria, awareness of this issue has led to government intervention (Zaghlami, 2016); in Nigeria, members of the Nigerian Young Academy have embarked on plagiarism awareness workshops (Nordling, 2018); and in South Africa, a high-level conference on publication ethics and integrity was followed by the publication of a statement on publication ethics, endorsed by key role players representing national government, academic institutions, advisory, and funding bodies in the country (Carruthers, 2019).

While the fact that fabrication or falsification were rarely cited as reasons for retraction in this study can indeed be seen in a positive light, this risk factor should not be underestimated. Indeed, if fabrication or falsification (12 mentions) is clustered with error in data, analysis or conclusion (47 mentions) as well as author misconduct (6 mentions), it appears that the same kind of issues that are problematical for authors in the global north, are also applicable to authors in Africa (Karabag & Berggren, 2016; Lei & Zhang, 2018). Publications containing fabricated or falsified data are generally deemed most damaging for the scientific enterprise and those who might become victims of applied fraudulent research (Chen et al., 2013; Stern et al., 2014). Hence, on-going awareness raising about risks and good research practice, as well as a culture of no tolerance for fraudulent research should be cultivated and maintained.

Objections by third parties were listed in 23 instances, and such objections could have been caused by any number of possible problems, ranging from unauthorized publication or use of data, to breaches in contractual obligations. Again, training and awareness raising, and measures to deal with deviations from best practice may help to prevent such issues. Retractions due to conflict of interest (2 mentions) and copyright issues (6 mentions) were rarely cited, but authors such as Rohwer et al. (2017) point out that insufficient knowledge about such issues does pose a risk for researchers and the research enterprise, which need to be addressed through training.

- Our second question, “*Are there specific areas of research, or characteristics of researchers or research teams (e.g., in terms of relative seniority or gender) which appear more frequently in the Retraction Watch database?*” was addressed when statistical tests for association were performed.

There are conflicting views in the literature regarding gender and misconduct: Fang et al. (2013) reported that males were “overrepresented” among researchers found guilty of research misconduct according to annual reports of the US Office of Research Integrity, whereas Fanelli et al. (2015) did not find evidence of gender playing a role in propensity toward misconduct. Our dataset of retracted articles contained a majority of male (74%) versus female (26%) first authors—a ratio of 2.8:1. While male authors also appear to represent a majority in relation to all research output from Africa (Larivière et al., 2013), there is a general lack of comparable bibliometric information that is gender-aggregated for the African continent from which definite comparisons and conclusions can be drawn.

We were not able to find any association between reasons for misconduct and gender but did find a significant association between gender and whether a retracted article had been single- or co-authored, with female first authors more likely to be involved in co-authored articles. This is an interesting finding, which could be related to what is often described as female gender traits of collaboration and willingness to support and acknowledge teamwork (Chandler, 2011; Gipson et al., 2017). However, given the fact that the focus of this study was on negative outcomes in the form of retracted articles, it would be useful to compare our finding with a sample of all publications from the African continent to see if the same trends and traits remain evident.

Other significant associations that were found in relation to specific reasons for retraction are broadly linked to types of collaboration and authorship teams, and subject field. In general, it appears that international collaboration may reduce the risk of retraction when it comes to plagiarism and errors in data. Articles by authors from a single African country were more likely to be retracted because of plagiarism, and articles by authors from more than one African country, due to error in data, analysis or conclusion than articles involving co-authors from outside the continent. This could imply that international collaboration might be associated with better internal processes of writing and reviewing manuscripts before they are submitted for publication (Tang et al., 2020) as well as better access to resources. This is a positive finding and supports the idea of international collaboration in research and research publication.

However, international collaboration may also lead to problems if not properly managed. Pouris and Ho (2014) found that researchers in Africa are generally more collaborative than their global counterparts when it comes to publishing and co-authorship, and ventured that this was due to the dependence of African researchers on international research funding. Our finding that retractions due to authorship issues appeared to be more prevalent when articles were co-authored by authors from within and from outside Africa may point to possible communication problems or possibly uneven power relations (see also Kombe et al., 2014; Munung et al., 2017). The *Montreal Statement on Research Integrity in Cross-Boundary Research Collaborations* (Third World Conference on Research Integrity, 2013) addresses such issues in two of its 20 principles, namely “Publication” (17) and “Authorship

and Acknowledgement” (18), where researchers involved in (cross-boundary) collaborative work are encouraged to communicate, plan and agree in advance on deliverables and to ensure that everybody who had made a contribution to a publication is appropriately acknowledged.

We also found a significant association between seniority of the research team and plagiarism as reason for retraction. If at least one member of the team of authors was at the level of professor or equivalent, plagiarism was less likely to feature as reason for retraction. This is a positive finding, implying that co-authorship with experienced, senior colleagues may bring benefits of better mentorship, review and quality control prior to manuscript submission. In fact, our finding that co-authored articles were less likely to be retracted due to plagiarism than single-authored ones again point to the benefits of teamwork and internal quality control prior to submission of a manuscript. Tang et al. (2020) reported similar findings about the benefits of teamwork when considering the likelihood of retraction in general. Fanelli et al. (2019), when considering image duplication as a reason for retraction, found that misconduct of this nature was more likely in long-distance collaborations that involved early-career first authors—once again pointing to the potential benefit of involving senior colleagues as co-authors.

A more negative finding that emerged from our study was that teams with at least one senior author were more likely to be involved in retractions due to duplicated articles. This may be ascribed to the academic culture of “publish or perish,” or the possibility that senior researchers—or multiple members of authorship teams—do not always keep proper track of similar manuscripts that are being submitted concurrently, sometimes by different members of the team, to different publication outlets. The latter deduction is corroborated by another finding from our study, namely that co-authored articles were more likely to be retracted because of duplication than single-authored articles.

For plagiarism listed as reason for retraction, there was a significant association with subject field: Articles from fields more aligned with the broad Social Sciences (Business/Technology, Environmental Studies, Humanities and Social Science) were more often associated with plagiarism as reason for retraction than articles in the Natural and Health Sciences. This seems to be supported by authors such as Karabag and Berggren (2016) and Grieneisen and Zhang (2012). Restricting the analysis to the four study fields with the most retracted articles (Business/Technology, Basic and Life Sciences, Health Sciences and Physical Sciences), a significant association with author misconduct became apparent. This finding is broadly in line with results from other studies, where retractions due to misconduct are concentrated in the medical, biological and health-related fields (Grieneisen & Zhang, 2012; Shuai et al., 2017).

The higher prevalence of retracted articles in the Basic Life Sciences and Health Sciences in particular (146/245, or 59.60%) can certainly be ascribed to the higher levels of academic publication in these fields (Table 3, based on UNESCO, 2015)). However, Grieneisen and Zhang (2012) found that retraction rates, compared to publication rates, were also higher in the four broad fields of Medicine, Chemistry, Life Sciences and Multidisciplinary Sciences than in the eight broad fields of Engineering and Technology, Social Sciences, Mathematics, Physics, Agriculture, Earth and Space Sciences, Ecology and Natural Resources, and

**Table 3.** Cumulative Publication Totals by Research Field in African Countries, 2014 to 2018.

	Agriculture	Astronomy	Biol Sciences	Chemistry	Computer science	Engineering	Geosciences	Mathematics	Medical sciences	Other life sciences	Physics	Psychology	Social Sciences	Total
Algeria	268	95	945	1586	393	3177	708	974	451	0	2194	0	729	11520
Angola	2	0	48	8	0	8	38	1	61	2	1	1	1	171
Benin	207	0	471	6	0	6	95	22	259	3	99	3	22	1193
Botswana	58	1	298	76	7	41	140	62	162	24	23	9	25	926
Burkina Faso	94	7	532	39	2	49	90	35	394	5	22	1	26	1296
Burundi	4	0	23	12	0	0	20	1	16	1	5	0	5	87
Cabo Verde	3	0	23	2	3	0	33	5	7	0	0	0	2	78
Cameroon	203	7	1132	189	15	179	326	134	577	11	369	3	45	3190
Central African Republic	0	0	81	0	0	2	13	3	31	0	2	3	0	135
Chad	1	3	27	0	0	0	23	1	27	1	1	0	3	87
Congo (Democratic Republic)	17	0	192	16	0	6	50	1	216	5	5	4	9	521
Congo (Republic)	19	0	210	10	0	8	44	7	176	3	19	4	11	511
Côte d'Ivoire	78	2	427	78	0	27	114	50	302	0	21	10	5	1114
Djibouti	0	0	6	6	0	1	12	0	11	0	1	0	0	37
Egypt	1338	185	6653	7036	608	5918	2141	1126	8346	72	3968	36	96	37523
Eritrea	5	0	17	5	0	2	23	3	20	0	3	0	4	82
Ethiopia	414	14	866	120	6	51	451	38	1000	24	111	8	117	3220
Gabon	6	0	323	3	0	6	37	12	153	1	14	10	3	568
Gambia	6	0	286	1	0	1	6	1	204	3	1	1	8	518
Ghana	255	0	648	70	5	160	336	13	782	32	26	4	85	2416
Guinea	6	0	67	6	0	3	8	2	58	0	0	2	2	154
Guinea-Bissau	1	0	76	0	0	0	4	0	54	1	0	0	0	136
Kenya	587	6	2626	91	7	90	505	16	1773	74	68	49	205	6097
Lesotho	15	0	23	7	1	11	7	4	22	9	7	0	1	107
Liberia	1	0	13	1	0	3	0	0	23	4	1	0	0	46
Libya	21	1	162	124	12	115	93	19	153	1	53	2	3	759
Madagascar	58	0	524	29	0	17	102	13	171	1	18	18	8	959
Malawi	76	0	470	3	1	23	80	3	601	39	7	5	34	1342
Mali	75	0	292	7	1	8	45	6	261	5	2	1	8	711
Mauritania	8	0	35	18	0	5	28	4	21	0	1	0	0	120
Mauritius	24	2	131	59	6	29	58	22	43	7	18	2	6	407
Morocco	243	26	1049	1382	133	923	836	800	1870	6	1436	13	36	8753
Mozambique	31	0	232	9	0	7	104	3	256	9	7	0	20	678
Namibia	13	77	194	7	3	16	125	6	69	9	16	3	3	541
Niger	66	1	160	10	1	6	91	9	103	2	7	2	7	465
Nigeria	1250	116	2261	495	37	750	862	163	2747	87	266	30	109	9173
Rwanda	31	2	144	3	3	10	33	2	195	6	16	4	11	460
Senegal	118	0	559	87	7	46	189	78	478	4	71	4	33	1674
Seychelles	2	0	72	0	0	0	44	0	30	0	0	4	3	155
Sierra Leone	10	0	41	1	0	7	0	0	68	3	1	1	5	137
South Africa	1863	1398	13696	4329	386	3655	5022	1714	8758	470	3424	272	749	45736
Sudan	141	27	389	131	17	70	72	10	427	6	60	2	10	1362
Swaziland	17	0	69	10	1	10	17	9	26	9	9	1	3	181
Tanzania	17	1	1045	41	8	80	336	4	1278	51	23	15	94	2993
Togo	37	0	111	5	0	21	15	7	89	2	12	1	1	301
Tunisia	1081	40	3808	1706	442	2436	1516	1184	2573	6	1485	18	117	16412
Uganda	157	5	1310	12	10	36	192	13	1229	71	13	36	82	3166
Zambia	29	0	423	3	1	14	61	0	478	22	12	3	37	1083
Zimbabwe	173	0	534	9	2	21	161	13	318	12	9	5	34	1291
<b>Total</b>	<b>9129</b>	<b>2016</b>	<b>43724</b>	<b>17848</b>	<b>2118</b>	<b>18054</b>	<b>15306</b>	<b>6593</b>	<b>37367</b>	<b>1103</b>	<b>13927</b>	<b>590</b>	<b>2817</b>	<b>170592</b>
<b>Percentage of all publications</b>	<b>5.4%</b>	<b>1.2%</b>	<b>25.6%</b>	<b>10.5%</b>	<b>1.2%</b>	<b>10.6%</b>	<b>9.0%</b>	<b>3.9%</b>	<b>21.9%</b>	<b>0.6%</b>	<b>8.2%</b>	<b>0.3%</b>	<b>1.7%</b>	<b>100.0%</b>

Note. UNESCO, 2015—data obtained from figures appearing on p. 445, West Africa—p. 485, Central & East Africa—p. 515, and Southern Africa—p. 545.

Humanities. Possible reasons for such inter-disciplinary differences could be due to different norms used to validate knowledge in different disciplines (Tang et al., 2020), or more stringent levels of regulatory oversight associated with the Biomedical and Health Sciences (Hesselmann et al., 2017; Van Zyl et al., 2019).

Unlike Grieneisen and Zhang (2012) who found that individual, remarkably prolific “repeat offenders”—often representing high-profile cases—tended to skew findings about retractions in relation to specific countries, subject fields or journals, we did not find that the contributions of single or same authors with multiple retractions had a major impact on findings emanating from our study.

- Our third question, “*What areas or issues should be prioritised in research integrity training or awareness raising initiatives, to reduce the risk of misconduct or questionable research practices?*” has to a large extent been answered by the findings from our study.

Our findings point to a clear need for better training and practical support in relation to scholarly publication practices—with plagiarism, authorship issues and duplication of articles requiring prioritized attention. The good news is that much is already being done in this field and it appears that even small interventions, if understood and applied across the system, may yield positive results, affording savings and benefits across the system. For instance, Stretton et al. (2012) as well as Steen et al. (2013) indicated that plagiarism and duplication as reasons for retraction were associated with single, rather than with repeat “offenders.” This could imply that, once an author has been made aware of such issues, he or she would be unlikely to persist. Hence, there is a need for more, better, and perhaps more targeted interventions to help raise awareness, a need for more effective and possibly more accessible systems and resources for quality control, better guidelines and recognition of teamwork and co-authorship, and also for more consistency in terms of policies and responses to transgressions across the system.

Apart from apparent “low-hanging fruit” in relation to best practices for scholarly authors, our findings also point to the need for on-going awareness raising and training for researchers at all levels about other aspects of research misconduct and questionable research practices. Emerging and established researchers, as well as other actors in the field, need to remain alert to the risks and possible repercussions thereof, how to avoid or recognize risky behavior, and how to respond to allegations or actual instances of misconduct.

The benefits of mentorship and collaboration to encourage good research practice emerged from associations that were found between collaboration with co-authors from countries outside Africa, and involvement of senior co-authors. The value of mentorship in academic development were also mentioned by Foo (2011) as well as Rohwer et al. (2017), while Hosseini et al. (2018) referred to good mentorship as “essential to ensure the professional development and ethical maturation of future scientists” (p. 204).

These findings underpin our recommendations for best practice, further research, and implications for education, below.

**Table 4.** Best Practices, Research Agenda and Implications for Education.

Best practice	National governments	<p>Reassess guidance and incentives for research productivity and align relevant legislation, policies and funding</p> <p>Reconsider funding streams and incentives that reward productivity at the expense of research quality or other academic work such as training, peer or ethics review and mentorship</p> <p>Develop and implement national policies to deal with research misconduct and promote research integrity</p> <p>Promote both education (awareness raising and positive support) and sanction (punishment for proven transgressors)</p> <p>Make resources to support the promotion of research integrity available to all entities required to abide by such rules</p>
	Funding agencies	<p>Publish or endorse statements about good research and publication practice</p> <p>Include specific conditions that require adherence to good research practice in funding contracts</p> <p>Introduce or strengthen criteria for evaluation and reward of researchers that focus more on the quality, relevance and collaborative nature of past research, than on individual publication-related productivity</p> <p>Allocate funds to support research, conferences or workshops on research integrity</p> <p>Provide financial support for the development of resource materials that can be made available to a broader audience</p> <p>Support the establishment of a helpline or central support office to help individuals or institutions who are uncertain about dealing with integrity-related questions or allegations</p>
	Academic publishers/journal editors	<p>Require appropriate sign-off of manuscripts before submission</p> <p>Screen for text similarity before sending manuscripts for peer review</p> <p>Improve quality of peer review through training and recognition</p> <p>Publish and apply clear guidelines on how to handle retractions and how to formulate retraction notices</p> <p>Improve and standardize formulations of retraction notices</p> <p>Distinguish between retractions due to good science citizenship, and those due to misconduct or questionable research practices</p>
	Research and academic training institutions	<p>Develop clear policies and procedures for responsible conduct of research and associated authorship practices.</p> <p>Provide resources (i.e., staff, support structures and software applications) to actively promote best practice</p> <p>Develop and ensure proper dissemination of clear procedures to deal with allegations of misconduct and ensure that sanctions, when needed, are applied transparently and consistently</p> <p>Introduce compulsory modules on research integrity, including responsible publication practices, as part of undergraduate and postgraduate curricula</p> <p>Encourage senior academics to offer or participate in training about research integrity, as part of continuous professional development requirements for faculty</p> <p>Promote collaborative research practice by introducing performance appraisal measures that focus on quality and relevance of publications, collaborative networks and mentorship</p> <p>Offer institutional support for researchers involved in internationally funded research projects for example, legal advice when negotiating terms and conditions of funding agreements, rights to publish and steps to ensure proper sign-off of manuscripts by all authors</p> <p>Make information on retractions or cases of misconduct available in a transparent and clear manner</p>
	Researchers	<p>Participate in awareness-raising programs about research integrity and best authorship practice both as presenters and participants</p> <p>Develop proper skills for communication and information management</p>
	The popular (mass or social) media	<p>Refrain from reporting instances of retraction or research misconduct in a sensation-seeking manner</p> <p>Present the facts associated with the decision to retract in a balanced manner</p>
Research agenda	Researchers (to inform national governments, funding agencies, or academic institutions)	<p>More detailed analyses per country, over a longer period, to inform country-level priorities for policies or training interventions</p> <p>Financial implications of retractions and who is carrying the greatest burden of such wastage</p> <p>Further work in relation to gender, publication and retraction</p> <p>Potential impact of language or culture on different kinds of misconduct</p>
Implications for education	Researchers (to inform academic institutions or professional associations)	<p>More detailed analyses of reasons and relative frequency of retractions according to field of study, to develop tailor-made interventions</p>
	National governments, funding agencies, professional bodies and academic institutions	<p>Develop and offer training or awareness-raising programs to address risk factors that should be mitigated, and types of misconduct that should be avoided, aimed at different audiences such as students, researchers, administrators, peer reviewers, editors, and policy makers</p> <p>Develop and offer training programs, policies and guidelines to support ethical publication practices</p> <p>Guidelines and training interventions to help prevent research misconduct or questionable practices leading to retractions should be made available to as many institutions or individuals as possible and not be limited to those privileged to have substantial levels of funding or collaborative networks</p>

## Recommendations

Similar to the 2010 Singapore Statement on research integrity (Second World Conference on Research Integrity, 2010) we direct our recommendations to various role players in the research enterprise, namely national governments, funding agencies, academic publishers, research and academic training institutions, emerging and established researchers, as well as the media. We present considerations to help promote best practice, propose a research agenda, and highlight implications for education. These are also summarized in Table 4.

## Best Practices

*National governments* are able to provide guidance and incentives through legislation, policies and funding. Lower risks and prevalence of research misconduct seem to be associated with the existence of national policies to deal with research misconduct (Fanelli et al., 2015; He, 2013). While many developed countries have well-established institutional and/or national systems in place to deal with reports and cases of research misconduct, most low- to middle-income countries do not have national bodies that have been tasked with dealing with such issues (Ana et al., 2013). At the same time, funding streams and incentives that reward productivity at the expense of research quality or other academic work such as training, peer or ethics review and mentorship, might fuel misconduct or questionable research practices. It has also been argued that national systems that reward academics for the quantity of their output, could contribute to a culture of opportunism where duplication of articles or so-called salami-slicing become common (Van Zyl et al., 2019). This also makes authors vulnerable to predatory publishers as has been demonstrated in South Africa where the introduction of an incentive funding system by the Department of Higher Education and Training in 2005 saw the number of article units double in the next decade, but with many of these articles published in predatory journals (Mouton & Valentine, 2017). Rossouw et al. (2014) emphasized the importance of national policies and support structures to help promote research integrity, and Van Zyl et al. (2019) indicated that the African continent seems to be lagging behind in this regard. There are however promising examples of national governments or advisory bodies in Africa starting to address this gap (Van Zyl et al., 2019).

Our research suggests that there is a need for clear policies and guidelines to promote research integrity at national level, and which can be applied at institutional level. Such guidelines should ideally outline shared values underpinning responsible conduct of research, explain what research misconduct entails, how it can be avoided or should be dealt with, and also include reference to resources that are made available to support such national policies and sanctions that will come into effect if policies are not adhered to. When discussing new legislation and guidelines that came into effect in China to promote research integrity and deal with cases of misconduct, Lei and Zhang (2018) highlighted that both education (awareness raising and positive support) and sanction (punishment for proven transgressors) are important in a culture where high stakes are placed on research productivity. We endorse this statement and add that—in the spirit of fairness and justice—resources to support the promotion of research integrity should be made available to all entities required to abide by such rules. Well-resourced institutions in a particular country often have access to skills, funding and other resources to develop training courses, support



programs and dedicated units to deal with queries or allegations while historically disadvantaged institutions in the same country usually lack such resources, which means that their students and academics remain at a disadvantage and at greater risk in increasingly competitive environments.

*Funding agencies* can also play a prominent role in promoting responsible conduct of research in ways that the risk of misconduct and retractions is reduced, while best practices are promoted. Such agencies can publish or endorse statements about good research or publication practice. This happened in South Africa in 2019 when the “statement on ethical research and scholarly publishing practices” was issued by the Academy of Science of South Africa (ASSAf), Council for Higher Education (CHE), Department of Higher Education and Training (DHET), National Research Foundation (NRF) and Universities South Africa (USA). Funding agencies can also include specific conditions that require adherence to good research practice in funding contracts outlining the conditions of grants. In addition, the following can also be considered:

- Introducing or strengthening criteria for evaluation and reward of researchers and grant applications that focus more on the quality, relevance and collaborative nature of past research than on individual publication-related productivity,
- Allocating funds to support research on research integrity or for conferences or workshops dealing with the topic,
- Providing financial support for the development of resource materials that can be made available for training or awareness raising at inter- or intra-institutional levels, or published on-line for a broader audience, or
- Supporting the establishment of a helpline or central support office to help individuals or institutions who are uncertain about dealing with authorship issues or other integrity-related questions or allegations.

*Academic publishers or journal editors* already play an important role in the fostering of good publication practice. Editorial policies of scholarly journals often have in place requirements for appropriate sign-off of manuscripts before submission, or screening for similarities in text before a manuscript is sent for peer review. Such requirements, if consistently applied, could help to reduce the occurrence of some of the more frequently-cited reasons for retractions in our study, such as plagiarism, duplicated publications and authorship issues.

It is also possible that problems leading to retractions might have been identified and resolved prior to publication, had the peer review of some articles been more rigorous. Suggestions to improve the quality of peer reviews include better training and recognition of peer reviewers, as well as efforts to reduce the numbers of manuscripts that are accepted for review. The Committee on Publication Ethics (COPE) and International Committee of Medical Journal Editors (ICJME) provide excellent guidance to journal editors and other interested persons about ethical publication practices and on how to deal with alleged, suspected or actual transgressions.

Some academic publishers also provide specific guidelines on how to handle retraction, and how to formulate retraction notices. Nevertheless, our study identified some areas for

possible further improvement. We found that the *Retraction Watch* database contained almost 100 different reasons for retraction, and had to cluster and code reasons before meaningful analysis could be done. As expected, we also found that some of the reasons listed for retraction were requests for correction received from authors, or had to do with errors by others involved in the publication pipeline, for instance journal editors or publishers. Such reasons could not be ascribed to misconduct or questionable research practices of authors. Authors such as Schmidt (2018) indicated that there is scope for improvement in formulation of journal policies on retraction and a need to use standard terminology in the formulation of retraction notices. Others such as Hosseini et al. (2018) and Stavale et al. (2019) urged for a clearer distinction between retractions that are due to good science citizenship, such as corrections or revisions, and retractions that are due to misconduct or questionable research practices.

*Research and academic training institutions* can provide support at several fronts to reduce the risk of unnecessary retractions. Clear policies and procedures about responsible conduct of research and associated authorship practices are needed. The implementation of such policies could be accompanied by providing resources, including staff, support structures and software applications, to actively promote best practice. Procedures to deal with allegations of misconduct should be clear. Sanctions, when needed, should be applied clearly and consistently. Training and awareness-raising initiatives to improve knowledge and adherence to research integrity and ethical publication practices need to be institutionalized. Such initiatives can be aimed at researchers as well as research administrators in different stages of career development. Compulsory modules on research integrity could, for instance, form part of undergraduate or postgraduate curricula, and more senior academics could be required to offer training or participate in regular workshops about aspects of research integrity as part of continuous professional development requirements for faculty.

Our findings also suggested that teamwork and involvement of senior academics in the preparation of manuscripts may reduce the risk of misconduct and retractions. Research institutions can help to promote collaborative research practice by introducing performance appraisal measures for academics that focus less on number of publications, and more on quality and relevance of publication, collaborative networks and mentorship activities. Institutional support for researchers involved in internationally-funded research projects may include legal advice when negotiating terms and conditions of funding agreements, notably rights to publish and steps to ensure proper sign-off of manuscripts by all authors, before submitting for publication.

*Established* as well as *emerging researchers* have clear responsibilities when it comes to the preparation and submission of manuscripts with a view to publication. Honesty, integrity, and attention to detail will most likely reduce the risk of misconduct while respect for others should ideally reduce the risk of questionable research practice. The risk of retraction due to duplication or authorship issues could be reduced by proper communication and information management among authors. Researchers should be encouraged to be involved in awareness-raising programs about research integrity and best authorship practice both as presenters and participants.

Finally, some attention can be given to the *popular (mass or social) media*. Instances of retraction or of research misconduct are sometimes reported on in sensation-seeking manners, rather than to present the facts associated with the decision to retract in a balanced manner (He, 2013). Here research institutions as well as journal editors can play a role by making information on retractions or cases of misconduct available transparently and clearly, rather than to be secretive and unprepared for scrutiny from news writers.

### **Research Agenda**

This exploratory study helped us to identify areas for further work. While we specifically refrained from comparing countries and regions with one other, more detailed analysis per country, over a longer period, might yield insights that can help to inform country-level priorities for policies or training interventions. The potential impact of language on different kinds of misconduct has not been explored in detail in this study. Interesting findings about Anglophone versus non-Anglophone countries in relation to reasons for retraction might emerge from future work.

More detailed analysis of field of study and reasons and relative frequency of retractions may also yield information relevant to more tailor-made intervention or awareness-raising programs for academics at all levels. It may be interesting to do a study on the financial implications of retractions and who is carrying the greatest burden of such wastage. Further work in relation to gender, publication and collaboration is also needed.

### **Educational Implications**

Findings from the study can be used in a variety of training or awareness-raising programs aimed at students, researchers, administrators, peer reviewers, editors, or policy makers—to make them aware of risk factors that should be mitigated, and types of misconduct that should be avoided or eliminated. The study has also helped to identify priorities for intervention, namely training programs, policies and guidelines to support ethical publication practices. We further strongly recommend that whatever is developed to improve best practice should be made available to as many institutions or individuals as possible, so that intervention programs should help to uphold and improve the quality and integrity of all research publications from the African continent rather than from a few select institutions.

In conclusion, we reflect on strengths and limitations of our study. In terms of limitations, it should be emphasized that this study was exploratory in nature—it tested for associations, which should not be interpreted as indicating causality (Fanelli et al., 2019). Further work will be needed to better understand some of the associations we found—or did not find. The *Retraction Watch* database that was used for our study is a very useful resource but does not claim to systematically and comprehensively cover all the cases of retraction over a given time period. Rather, it provides a good overview of trends. There were also other limitations to the source data in the context of our study. For instance, we were not able to reflect dual country affiliation when sorting records of retracted articles per country level: Where some articles were associated with more than one African country, we had to assign them to only one African country for purposes of country-level analysis. Another constraint

was that author information appearing in the database was rather limited, and could appear with different versions of names, initials, surnames or institutional affiliations, making it difficult to spot all instances of multiple retractions, and reducing our ability to assign gender and seniority to all authors listed. In addition, there is a dearth of bibliometric information for the African continent to compare with findings from our study and allow for further exploration of research questions or ideas.

Strengths of the study include the following: The study explored a topic that is currently under-researched for the African continent. As far as we know, this particular analysis of retracted articles is a first for Africa. Our specific interest in implications for training and awareness-raising initiatives brings a positive perspective to the work on retractions. We have identified several strands for future research and collaborative interventions that need not cost much but may yield positive results for researchers and research production on the African continent—and beyond.

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**ORCID iD:** Theresa M. Rossouw. <https://orcid.org/0000-0003-4066-922X>

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### **Author Biographies**

**Theresa M. Rossouw** is professor in Immunology at the University of Pretoria and chairperson of the Research Ethics Committee of the Human Sciences Research Council. She is actively involved in research ethics and integrity training.

**Liapeng Matsau** is deputy director, Research of the South African Qualifications Authority. She has worked on the promotion of research integrity which included in-house training and institutional policy development.

**Christa van Zyl** is a Director in the Office of the Deputy CEO, Research of the Human Sciences Research Council. Her involvement in the field of research ethics and integrity includes policy development and review, in-house training and awareness raising, information sharing with colleagues through the African Research Integrity Network, and occasional co-authored publications.