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Trust Me, I'm a Scientist

KU LEUVEN

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Trust Me, I'm a Scientist

Research Integrity and Misconduct within Biomedical Research

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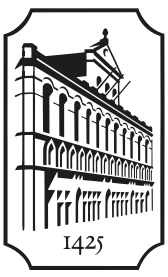
TRUST ME, I'M A SCIENTIST

RESEARCH INTEGRITY AND MISCONDUCT WITHIN BIOMEDICAL RESEARCH



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I dedicate this PhD thesis to my wife, my son, my entire family. My late grandfather admired researchers more than influential world leaders, visionary business men and women, and religious leaders. He praised their determined and continuous search for the truth. This PhD is born out of that admiration. Research is of paramount importance to our society. Therefore, the issues of research integrity and misconduct need to be examined. One of our interviewees phrased it as follows:

> "Research is the best thing we have in our culture, I'm certain of it. It is the best we have, and therefore we need to keep it pure."

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General introduction

Research integrity and misconduct

Research misconduct

Scandals concerning research misconduct are frequently and widely discussed in leading academic journals, as well as in the press.[1-3] Renowned researchers proved to have plagiarized (copying of ideas, data, or words without attribution), falsified (willfully manipulated/ distorted data or results) and fabricated (invented data or cases) research data.[4-8] Also within biomedical industry, research misconduct has been documented.[9]

It is important to act on research misconduct, because it harms the prevailing ethos of biomedical research by undermining the norms and standards of rigorous scientific conduct.[10] It also questions the foundational trustworthiness of biomedical research. This trust consists of both the public's trust in biomedical research as well as the mutual trust of biomedical researchers within the international scientific community. Given that current biomedical research is more than ever before a collective undertaking, both interdisciplinary and international,[11] a breach in trust has a huge impact.[12] Biomedical research and research in general relies to a great extent on the research findings, judgments and recognition of other scientists. Therefore, Richard Smith describes research misconduct as "the poisoning of the well".[13] In addition, research takes place within a public society, and is often supported by that society, which implies that research has a social responsibility and should serve society and the universal well-

being of mankind.[12] Trust and support of society is jeopardized by research misconduct.

Integrity

When considering research integrity and misconduct within bio-medical research, we first need to consider the concept of integrity. The Stanford Encyclopedia of Philosophy refers to integrity as a virtue:

> "When used as a virtue term, "integrity" refers to a quality of a person's character; however there are other uses of the term. (…) Integrity is also attributed to various parts or aspects of a person's life. We speak of attributes such as professional, intellectual and artistic integrity. However, the most philosophically important sense of the term "integrity" relates to general character. Philosophers have been particularly concerned to understand what it is for a person to exhibit integrity throughout life. Acting with integrity on some particular important occasion will, philosophically speaking, always be explained in terms of broader features of a person's character and life. (…) Ordinary discourse about integrity involves two fundamental intuitions: first that integrity is primarily a formal relation one has to oneself or between parts or aspects of one's self; and second, that integrity is connected in an important way to acting morally, in other words, there are some substantive or normative constraints on what it is to act with integrity."[14]

Edgar Karssing links integrity to professional practice and states that integrity should be viewed as professional responsibility.[15] Within this approach, the elements of trustworthiness and the context are vital.

Acting with integrity is nevertheless challenging and requires courage. Robert Solomon even defines integrity as moral courage: "the will and willingness to do what one knows one ought to do".[16] John Kekes and Charles W. Marshall emphasize that someone can only be considered to be a person of integrity if he or she also acts ethically when it is difficult to do so.[15,17] Marshall defines integrity as follows:

> "Integrity is doing the right thing when you don't have to – when no one else is looking or will ever know – when there will be no congratulations or recognition for having done so."[17]

Clive S. Lewis stresses that doing the right thing for the wrong reasons, is not enough in the context of integrity:

> "We might think that, provided you did the right thing, it did not matter how or why you did it—whether you did it willingly or unwillingly, sulkily or cheerfully, through fear of public opinion or for its own sake. But the truth is that right actions done for the wrong reason do not help to build the internal quality or character called a 'virtue', and it is this quality or character that really matters."[18]

Integrity is thus not achieved when abiding by certain rules or doing what is wright, simply because you had no other options. If we would apply this requirement to the context of research integrity and misconduct, we would stimulate researchers to conduct their research in line with important principles, such as objectivity, reliability and responsibility. In addition, as Aristotle explained, we need to uphold

the necessary flexibility when dealing with practical situations.[19] The practical context of research is prone to continuous change and evolutions. Therefore, researchers continuously need to make new decisions, based on important principles, within a specific context, i.e. time and place.

Another approach aims to achieve desirable conduct by focusing on compliance towards rigorous rules. In line with this approach, several authors focus on control and power, rather than virtues. Within the theory of the *panopticon*, as described by Jeremy Bentham and later elaborated by Michel Foucault,[20-21] people abide by the norms because they continuously feel that they are or possibly could be observed or inspected. If this theory is applied to the context of research misconduct within biomedical research, the emphasis might be placed on frequent unannounced audits or inspections of laboratories.[22]

Guidance documents

The appearance of research misconduct within biomedical research raises the question whether there are no guidance documents concerning research integrity in Europe which might help biomedical researchers to balance their research actions. Research has namely showed that research misconduct is more likely to occur in countries that do not have research integrity guidance.[23] The elaboration and promotion of research integrity guidance and policy are important.[24]

> "The globalization of research demands greater collaboration between organizations that are responsible for ensuring standards of research

> integrity; the need for international standards and guidance has never been greater."[25]

However, when we started this research project, no overview existed of the national documents concerning the guidance on research integrity or the handling of allegations of misconduct of the countries belonging to the European Union (EU) and the European Free Trade Organization (EFTA). The European continent is characterized by great diversity, with countries having their own research agencies and different legal systems. Nevertheless, a considerable proportion of the world's research takes place in Europe (23% of the total global research and development in 2009 took place in the European Union[26]) and the European Commission underlines the importance of ethics in research, including research integrity:

> "For all activities funded by the European Union, ethics is an integral part of research from beginning to end, and ethical compliance is seen as pivotal to achieve real research excellence. It is only by getting the ethics right that research excellence can be achieved."[27]

Defining research misconduct and research integrity

Despite the profound impact of research misconduct, there is to date no international consensus on how research misconduct and research integrity should be defined. International collaborative research projects might be severely hampered by disagreements between countries concerning research integrity or misconduct. Nonetheless, in general, research actions or behaviors are often categorized on a continuum,

ranging from research integrity (proper research practices and behaviors) to research misconduct (unacceptable research practices and behaviors). Fabrication (inventing research data), falsification (wilfully distorting research results or data) and plagiarism (copying words, data, or ideas without giving due credit), also referred to as FFP, are generally considered to be the most serious forms of research misconduct.[28-30] Between these forms of research misconduct and acceptable research practices, there is a grey zone of questionable research practices. These practices are not as serious as research misconduct, but cannot be considered to be research integrity.

The approach taken towards research integrity and misconduct might differ between countries. Within Belgium for example a moral code, which focuses on values of research integrity, was developed rather than a more legalistic approach, including a (narrow) definition of research misconduct.[31] The federal government of the United States of America (USA), however, provides a clear definition of research misconduct as fabrication, falsification, or plagiarism. Nevertheless, several institutions in the US adopted definitions that include more elements, such as authorship related misconduct.[32]

Prevalence of research misconduct

Research conducted among biomedical researchers shows that the earlier mentioned questionable research practices are often encountered, and are more of a threat to science than outright fabrication, falsification or plagiarism.[33] These practices happen so often, that they

might be considered the 'normal' research practice. A meta-analysis of surveys on research misconduct indicated that 2% of researchers admitted to having fabricated and falsified at least once and 34% admitted questionable research practices. However, when asked about the conduct of their colleagues, researchers indicated that 14% of their colleagues had falsified data, and 72% would have engaged in questionable research practices.[8] 2% admitted to having committed plagiarism and 30% observed colleagues plagiarizing.[34] These percentages indicate that researchers do not fully trust their colleagues, despite the fact that trust is foundational to science.

Similarly, a survey sent out to 1353 participants of international research integrity conferences, showed that researchers were most concerned with selective reporting, selective citing, and inadequate quality assurance and mentoring.[35] Fabrication and falsification were considered to have the highest destructive impact on truth, but the estimated frequency was low.[35] Plagiarism, however, had a rather high estimated frequency, but its impact on truth was considered low.[35] Also a Delphi survey conducted among 40 experts estimated that fabrication and falsification occur rarely.[36] Another paper, however, stresses the importance of plagiarism.[37]

Prevention of research misconduct

Discussion exists concerning the prevention of research misconduct. On the one hand, the importance of research integrity training and mentoring is underlined.[23-24,38] In the USA for example, research integrity training is an obligatory requirement when applying for a

research funding with the National Institute of Health and the National Science Foundation.[39-40] Nick Steneck pleas for a further elaboration and global harmonization of research integrity trainings:

> "Shared acceptance of the "rules" for ethics and integrity are as essential to collaboration and progress in research as agreement on the basic laws of nature. Globalization of RCR training would harmonize and gain greater support for the common rules and professional standards for responsible research."[41]

On the other hand, the effectiveness of training and mentorship has been drawn into question. An USA survey demonstrated that in some cases research integrity training might even stimulate research misconduct. Additionally, depending on the kind, mentoring might decrease or increase the likelihood of research misconduct.[42]

The transparency concerning the conducted research by sharing the raw research data, has also been suggested to prevent research misconduct. It is, for example, mandatory to register a clinical trial prior to its beginning on an appropriate website, in order to be able to publish the outcomes.[43] Nevertheless, researchers appear to be reluctant to share their data, even after they already published their results.[44-46] In contrast, other researchers explicitly state that simply implementing further requirements for transparency is counterproductive. They might even form a severe threat to researchers. Researchers fall victim to "endless information requests, complaints to researchers' universities, online harassment, distortion of scientific findings, and even threats of violence."[47] They give an overview of several risk factors

and suggest clear conditions. For example, they underline the importance of sharing data, but they emphasize that researchers need to control how the data are used, keeping in mind the conditions to what the participants agreed upon.[47] When researchers are suspicious, an independent 'referee' might be appointed to judge the honesty and validity of the question to access the research data.

Industry versus universities

Recently, several studies have been conducted in Europe.[48-52] A lack of empirical data remains however concerning the issues of research integrity and misconduct within biomedical industry. The industrial influence is often considered as a major cause of research misconduct.[53-54] Conflicts of interest, financial gain, pressures of the funding source, are perceived as harmful for academic research. Pharmaceutical companies for example might want to leave out data that do not support the quality and validity of their products. When academic research is funded by such a company, researchers can feel pressured to report only those data that support the usefulness of the drug. According to Lisa Rosenbaum, this unfounded distrust towards biomedical industry has become so strong that mere transparency about industry involvement in research might immediately lead to an unfair dismissal of the results.

> "Proponents insist that transparency is key to maintaining public trust. If beliefs about physician–industry interactions were affect-neutral, that argument would make sense. But injecting transparency into a hostile

> climate virtually guarantees that fragments of information will be spun into insinuations of wrongdoing."[55]

Biomedical industry has an important role in the performed research and their research output often has a direct impact on biomedical research in general and on society. In addition, a lot of biomedical research is also performed in collaboration between industry and universities.

Objectives of the research

The objectives of our research are to tackle the three following main research goals:

- Comprehensive retrieval and comparative analysis of the research integrity guidance documents of the countries belonging to the European Union (EU) and European Free Trade Association (EFTA).

- Analyzing the perspectives, attitudes, behaviors, and ethical evaluation concerning research integrity and misconduct of biomedical researchers and research managers, active in universities or industry.

- Reflecting on the elaboration of a research integrity policy from an ethical perspective.

Empirical ethics

Throughout this PhD study we follow the approach of empirical ethics. Within empirical ethics it is advocated that "the study of people's actual moral beliefs, intuitions, behavior and reasoning yields information that is meaningful for ethics and should be the starting point for ethics."[56] Empirical ethics utilizes quantitative and qualitative research methods in order to collect empirical data concerning these elements. Thereby, empirical ethics relies on research methods that have been long used in the social sciences. Empirical ethics reveals facts regarding research integrity and misconduct which are relevant for the biomedical researchers and research managers. In addition, their perspectives, actions and challenges concerning research integrity and misconduct are a source of ethics in itself.[57] This empirical ethics approach affected our research goals, as well as our discussion of the findings.

When we would however unilateral start our reflection from rational principles or values, we risk of making assumptions without empirical grounds or reflect on elements which are not relevant for biomedical researchers and research managers themselves. Therefore, our approach might induce new and unanticipated issues for a bioethical research.

> "In line with approaches such as hermeneutics, casuistry, narrative ethics, and care ethics, empirical ethics attempts to answer this plea by locating

> ethical reflection in a social and historical context, influenced by cultural values and enriched by personal narratives."[57]

In order to get an overview of the perspective concerning the theory, understood as the ethical framework, we conduct a review of the official research integrity guidance documents of the countries belonging to the European Economic area in the first phase of our research. We aim to analyze the policy perspectives concerning research integrity and misconduct, including their definitions of research misconduct.

In the second phase of our research, we conduct a qualitative and a quantitative empirical study and focus on the ethical evaluation and lived experience concerning research integrity and misconduct of biomedical researchers and research managers. Already Aristotle claimed that ethics is a practical discipline.[19] This implies that ethics is familiar with the praxis and is willing to learn from the praxis. We plea for an inductive ethical approach characterized by an openness to the lived experiences concerning research integrity and misconduct of the biomedical researchers and research managers in their research context. Therefore, we want to analyze the perspectives, behaviors, lived experiences and morality concerning research integrity and misconduct of biomedical researchers and research managers, and its relations to several elements, including the context in which biomedical research is conducted. In addition we also investigate how these perspectives are related to the viewpoints of the research integrity guidance documents.

Finally, based on the two previous phases, we formulate a concluding reflection concerning the ethical implications of the elaboration of a research integrity policy, including several recommendations.

Phases of this PhD research

Phase one: Comprehensive retrieval and comparative analysis of the guidelines

Due to the lack of information on the regulatory framework regarding research integrity in Europe, we firstly perform a comprehensive retrieval and comparative analysis of the overview of the official research integrity guidance documents of the countries which in 2012 belonged to the EU and EFTA. Hereby, we intend to map the existing documents and analyze their perspectives concerning various issues of research integrity and misconduct.

We focused on the national level because no overview and no comparative analysis of the integrity guidance documents of the countries of the European Union (EU) and European Free Trade Association (EFTA) existed when our study was conducted. In addition, in our empirical studies we included both biomedical researchers and research managers active in universities and those active in industry. Therefore, we did not focus on research integrity guidance documents on the level of organizations for example.

When collecting these guidance documents, we took several steps (for example: contacting the organizations that published the guidance documents as well as experts concerning research integrity and misconduct) to ensure that the documents we retrieved were indeed the relevant documents for that country. Therefore, we trust that our

extensive search strategy led to the inclusion of the relevant existing guidance documents.

In our papers we also considered international guidance documents, including the Memorandum on Scientific Integrity published by All European Academies, the European Scientific Misconduct Strategy, the European Code of Conduct for Research Integrity, and the Singapore Statement on Research Integrity.[58-61]

Our research demonstrates that research integrity guidance is highly diverse in Europe. Therefore, we also search to explain why the research integrity regulatory framework differs so substantially throughout Europe, by distinguishing the approaches that underlie them. Firstly, we distinguish an approach that is strongly based on values, such as honesty, and thereby focused on the positive, desirable research conduct. Secondly, there is the approach that is more concerned with norms, and thereby emphasizes rules and sanctions when the rules are broken.

Phase two: Empirical studies focusing on the praxis

We perform a qualitative (interviews) and a quantitative study (survey) in order to analyze the perspectives, attitudes, behaviors and normativity concerning research integrity and misconduct of bio-medical researchers and research managers active in industry or universities. Including biomedical researchers and research managers from both industry and universities enables us to explore the similarities and differences concerning the earlier mentioned issues of research integrity and misconduct within these different contexts. We

choose to conduct both a qualitative and a quantitative study, because the combination of both approaches reveals the most comprehensive data and insight into the complexity of research integrity and misconduct from the perspective of biomedical researchers and research managers.

For our survey, we update and adapt a USA survey[33] on research integrity based on the findings of our review of the official guidance documents and the analysis of the 22 interviews. Interestingly, one of the authors of the USA survey, prof. Raymond De Vries, has already for some time defended the notion that methodologies common in social sciences, such as surveys, and the attention to the specificity of the context, are important when studying ethical decision making.[62]

We research how often the respondents admit they have committed actions of research misconduct or observed their colleagues committing them in the last three years. We investigate whether research misconduct is reported more frequently in industry compared to universities.

We inquire to various aspects, including their familiarity with the research integrity guidance documents, whether they themselves or their colleagues committed research misconduct, and how they ethically evaluate actions that are generally considered to be research misconduct. Hereby we research, among other elements, possible similarities or differences between their ethical evaluation of research misconduct compared to those of the research integrity guidance documents. In addition, we investigate the relation between this ethical evaluation and the reporting of research misconduct. In line

with the findings of previous research,[35-36] our respondents might also not consider some or all of these actions to be equally serious. There ethical evaluation is crucial for our research.

As stated earlier, it has been advocated that there is an ungrounded distrust from academia towards industry concerning research integrity.[55] Our research attempts to provide the much needed novel empirical data on these issues. Thwarting industry-university collaborations without grounded reason might hamper necessary research for patient's health benefits. Both the qualitative and the quantitative parts include people of both genders, and many different international backgrounds.

Because no previous research has compared industry and academia concerning research integrity, we focus on the situation in Belgium as a case study. Admittedly, this is a limited context, but the participants come from all over the world and there are no reasons to assume that the Belgian situation would greatly differ from other industrialized Western countries.

Phase three: Concluding ethical implications concerning the elaboration of a research integrity policy

Our research brings together guidance on the issues of research integrity and misconduct, with the daily research practice. Thanks to our inductive ethical approach, we gain insight into how normativity regarding research integrity and misconduct is formed within the context of daily practice of biomedical research. In this respect, our empirical ethical approach does not only bring to light the perspect-

ives, attitudes, behaviors, and experiences regarding research integrity and misconduct of the investigated populations, but also makes a substantial contribution to the concept of research integrity and misconduct as employed by the investigated populations. Our analysis reveals several relations with various factors concerning issues of research integrity and misconduct, and the abstract concept "research integrity" gains a realistic, empirically-based meaning.

Empirical studies involving biomedical researchers and research managers can provide data on which better applicable answers to questions concerning research integrity and misconduct can be formulated.[62] In order for biomedical researchers and research managers to acknowledge a research integrity policy, they need to be able to recognize their own perspectives, challenges and experiences in this policy. The compliance to a research integrity policy is influenced by whether biomedical researchers and research managers consider it to be familiar to their practice. If such a policy is perceived as a '*corpus alienum*', something that is strange and far removed from the daily research practice, it risks of having little impact.

A research integrity policy should be a continuous cyclic interaction between research integrity guidance and the data received from the daily praxis, combined with a consideration of the specificity of the context of biomedical research. Perspectives, attitudes and behaviors of the praxis need to be studied and considered. Based on this data, we need to continuously reflect on the fundamental values of research integrity within the current context in which biomedical researchers and research managers operate, in order to achieve and

maintain a research integrity policy that is acknowledged and adhered to by the biomedical researchers and research managers. A research integrity policy should however not solely be determined by the current practice of biomedical researchers and research managers. We should nevertheless talk with biomedical researchers and research managers, instead of talking about them.

Based on our analysis, we formulate several recommendations concerning the elaboration of a research integrity policy, considering among other elements the specificity of the context of biomedical research and the earlier mentioned distinction between a value- and a norm based approach towards research integrity guidance. We hypothesize that these recommendations will stimulate the continuous process of elaborating an agreed upon research integrity policy.

Output of this PhD research

Our research provides a comprehensive retrieval and comparative analysis of the national guidance documents of the European countries. Based upon our analysis of the empirical data, we come to a more comprehensive understanding of these issues from the perspective of biomedical researchers and research managers. Additionally, this enables a better fostering of research integrity.

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Phase one:

Review of guidance documents

Chapter one: Guidance on research integrity: no union in Europe

Published as:
Godecharle S., Nemery B., Dierickx K. (2013). Guidance on research integrity: no union in Europe. *The Lancet, 381* (9872), 1097-1098.

To clarify the regulatory framework regarding research integrity in Europe, we analyzed national official guidance documents on scientific integrity in the 27 countries of the European Union plus the four countries of the European Free Trade Association— i.e., Iceland, Liechtenstein, Norway, and Switzerland. We found a highly heterogeneous picture.

No guidelines could be analyzed for 12 countries (13% of the target population's published output[1]). We retrieved and analyzed 49 guidelines, published by 19 countries (see appendix for methods and detailed results). In general, the Nordic countries and most countries of central and western Europe have national guidelines to address research misconduct and promotion of research integrity (figure). Only Denmark and Norway have a specific law to deal with research misconduct, and many countries have multiple guidelines with seemingly little internal consensus. Not one list of principles or one definition is identical in any two guidelines (except for Denmark and Norway).

Fabrication, falsification, and plagiarism are evoked most frequently as forms of misconduct, although several guidelines recognise other possible forms. Some guidelines make explicit gradations and distinguish serious misconduct, such as data fabrication, from less serious forms, such as denying deserved authorship. Similar forms of misconduct are sometimes judged differently by different guidelines. For example, one Swedish guideline qualifies continued carelessness as misconduct, whereas Finnish guidelines consider carelessness as less serious than fabrication, which is qualified as fraud. The notions of intention, negligence, or deceit feature explicitly in certain definitions of misconduct, although the establishment of intentionality is acknowledged to be difficult.

The guidelines advocate various possible actions to prevent misconduct, although some also acknowledge that total prevention is impossible. Training and education in good research practice feature regularly, especially directed towards junior scientists. Only the Irish guidelines explicitly stress the need to instruct senior researchers also.

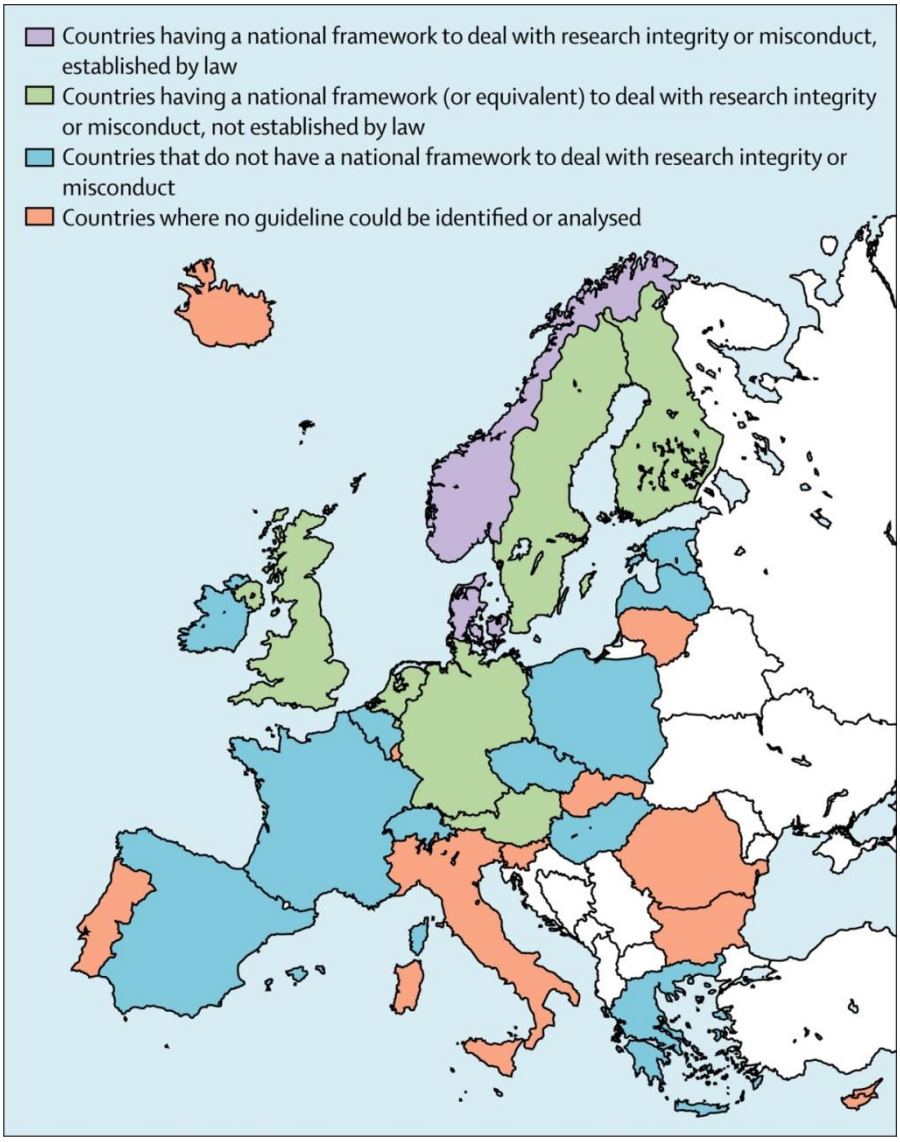
The observed heterogeneity in guidelines within and between European countries results in a confusing situation. We therefore support pleas for harmonisation of the guidance on research integrity in Europe.[2] The Memorandum on Scientific Integrity published by All European Academies (ALLEA) and others,[3] the European Scientific Misconduct Strategy published by the European Research Council,[4] and the European Code of Conduct for Research Integrity published by ALLEA and the European Science Foundation[5] are all steps in the right direction. However, these initiatives do not guarantee a unified

approach throughout Europe. Thus, for example, the Hungarian guideline contains marked discrepancies from the European Code of Conduct for Research Integrity, although it claims to be based on this code.

Finally, we had great difficulty in retrieving the guidelines of several countries. If these guidelines are so hard to find, how can they then serve as a framework for researchers? Moreover, how can researchers cooperate in international research projects with such diversity in guidelines? We have to conclude that European countries are not yet united when it comes to guiding scientific integrity.

Conflicts of interest: We declare that we have no conflicts of interest.

Figure 1: Classification of countries belonging to the European Union and European Free Trade Association according to some broad categories defined by how they deal with scientific integrity.



Adapted from:

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Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed.

Methods

We conducted a search of the documents on research integrity, involving either biomedical research or scientific research in general, from all 27 countries of the European Union plus the four countries of the European Free Trade Association, i.e. Iceland, Liechtenstein, Norway, and Switzerland. In the following, these documents, which include laws and guidelines, will be called "guidelines".

To identify these guidelines, we searched the internet (between 1 February 2012 and 18 July 2012) using Google, Google Scholar and PubMed, and the following search terms and their relevant combinations: "biomedical research", "scientific misconduct", "research misconduct", "research ethics", "scientific integrity", "mentoring", "education", "biomedical research", "mentor", "training", "bioethics", "models of prevention", "prevention of research misconduct", "prevention", "good scientific conduct", "responsible conduct of research", "disclosure", "self-disclosure", "guidelines", "scientific fraud", "fraudulent data", "misconduct in science", "questionable research", "questionable research practice", "fabrication", "falsification", "plagiarism", "Europe". We also added the names of the individual European countries. The retrieved guidelines were considered

for possible inclusion if they were published or explicitly referred to by one or more of the following national organizations: the bio-ethical committees listed by the World Health Organization (WHO),[1] the national academies of sciences belonging to All European Academies (ALLEA),[2] or a national research integrity governance framework, if any existed. Guidelines were included if they dealt with scientific research in general, or more specifically with biomedical research.

In a second phase we contacted each of the aforementioned organizations by e-mail, and asked them if the guidelines we had found were indeed the relevant guidelines for their country. If we had been unable to find any guidelines, we asked them whether guidelines existed concerning scientific integrity in their country. If these organizations referred explicitly to other guidelines, we investigated these as well. In a third phase we also contacted the national association of universities or an academic individual, such as someone who had published on scientific integrity or had spoken at the 1st or 2nd World Conference on Research Integrity.[3-4] We also asked them to confirm whether the guidelines we had found or received were indeed relevant.

All the retrieved guidelines were thematically analyzed by a single person (SG), provided they were available in English, French, German, Dutch or Italian. No statistical analyses were needed for this descriptive study. In the tables, the countries are identified by the official abbreviations for each country, as listed in e-figure 1. In the following the word misconduct refers to infringements on scientific integrity.

Results

For this study, we sent more than 340 specific e-mails, including reminder e-mails and messages requesting clarifications. The flow-chart shows how we ended up with 49 relevant guidelines, published by 19 countries.

No information was found for Liechtenstein; no guidelines could be identified or analyzed for 11 other countries. No guidelines on research integrity were retrieved for 7 countries (Bulgaria, Cyprus, Lithuania, Portugal, Romania, Slovenia, and Luxembourg) even after repeated contacts with individuals working in these countries. We were also unable to analyze guidelines from Slovakia, because these were only available in Slovak. In spite of a considerable amount of e-mail exchanges, Italy, Malta and Iceland could also not be included in our analysis because the documents received from these countries were not devoted to research integrity as such.

The 49 guidelines amenable to analysis are listed in e-table 1, together with the institution that developed the guideline, the year of publication, the title, word count and URL of the guideline. In the following, guidelines are identified by country code followed, if applicable, by a small capital letter, in square brackets: e.g. [FR(A)], as shown in e-table 1. Most guidelines (90%) were published between 2002 and 2012. The number of words (including references) ranged from 139 to 57287 words (median: 2467 words, 25th-75th percentile: 1377-5795).

E-table 2 summarizes the main (explicit) sources of inspiration for the guidelines. The structures that address research misconduct or promote research integrity in Europe differ markedly between countries. Only Denmark and Norway appear to have a specific law to deal with research misconduct [NO(A), DK(B,C)]; several other countries have more than one guideline with seemingly little internal consensus [IE(A-H), FR(A-C), PL(A,B), UK(A-G), ES(A,B)]. E-table 3 gives an overview of the principles to which the guidelines explicitly refer, and unacceptable actions or events that define misconduct in the guidelines.

A detailed analysis of how the various themes are addressed by each country will be published elsewhere.

Comments

Our review contains some methodological problems and limitations. We cannot completely rule out that some documents have been overlooked. It is conceivable that the institutions that we initially approached in each country do not play the most important role in safeguarding research integrity. However, we compensated for this limitation by contacting key persons in each country and including guidelines published by other institutions if our contacts had referred to these documents. So, we trust that our extensive and persistent search strategy led to the inclusion of all relevant existing guidelines. We are aware that the Medical Research Council of the UK has published an update of the guideline "Good research practice: principles and guidelines"[10] in August 2012, which has not been able

to be included in our analysis, because our search stopped on 18 July. Nevertheless, this guideline is based on the previous guideline published in 2002 [UK(C)], which is included in our review. We did not verify the accuracy of the English translated versions against the documents in the original languages, and it is conceivable that some nuances may have been lost in translation. However, it is unlikely that this has seriously affected our findings.

One could also object that we only investigated the guidelines of 19 of the 31 countries. However, these 19 countries are responsible for almost 90% of all citable scientific publications from our target population.[5] How research integrity is managed in the 12 other countries remains unclear. The absence of a national framework does not rule out the existence of local guidelines in universities or research institutions. Obviously the absence of national guidelines or a national structure to deal with research misconduct does not imply that the research in that country is not performed with integrity. In fact, it is remarkable that several countries, such as Germany, Austria and Norway, only established national frameworks after scandals concerning serious cases of misconduct had been revealed [IE(E)]. It is beyond the scope of this specific paper to judge whether guidelines published by national bodies are effective in ensuring research integrity.

Although relatively little research has been devoted to scientific integrity, our findings are compatible with those of other studies on this issue. Thus, the defensive attitude of certain guidelines towards competition corresponds with empirical research findings on how researchers perceive competition.[11] Consistent with research on research

misconduct,[12-13] several guidelines recognize that there are far more forms of misconduct than just outright fabrication, falsification and plagiarism. However, even though empirical research questions the efficiency of education and training in decreasing misconduct,[14] education and training are still the most recurring elements of prevention mentioned in the analyzed guidelines.

Role of the funding source

There was no involvement of the funding source. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Contributors

BN and KD contributed to the study design, the elaboration of the manuscript, and supervised the research. SG performed the search for documents concerning research integrity or misconduct, collected, analyzed and interpreted the data, wrote the first and successive drafts of the manuscript, figures, and tables. All authors have approved the final revision.

Conflicts of interest

All authors declare that they have no conflicts of interest.

Acknowledgements

We thank all our contacts for their cooperation. We thank Giovanni Pagliaro, a native Italian speaker and sworn Italian interpreter, for his help in translating Italian documents.

Figure 2: Flowchart.

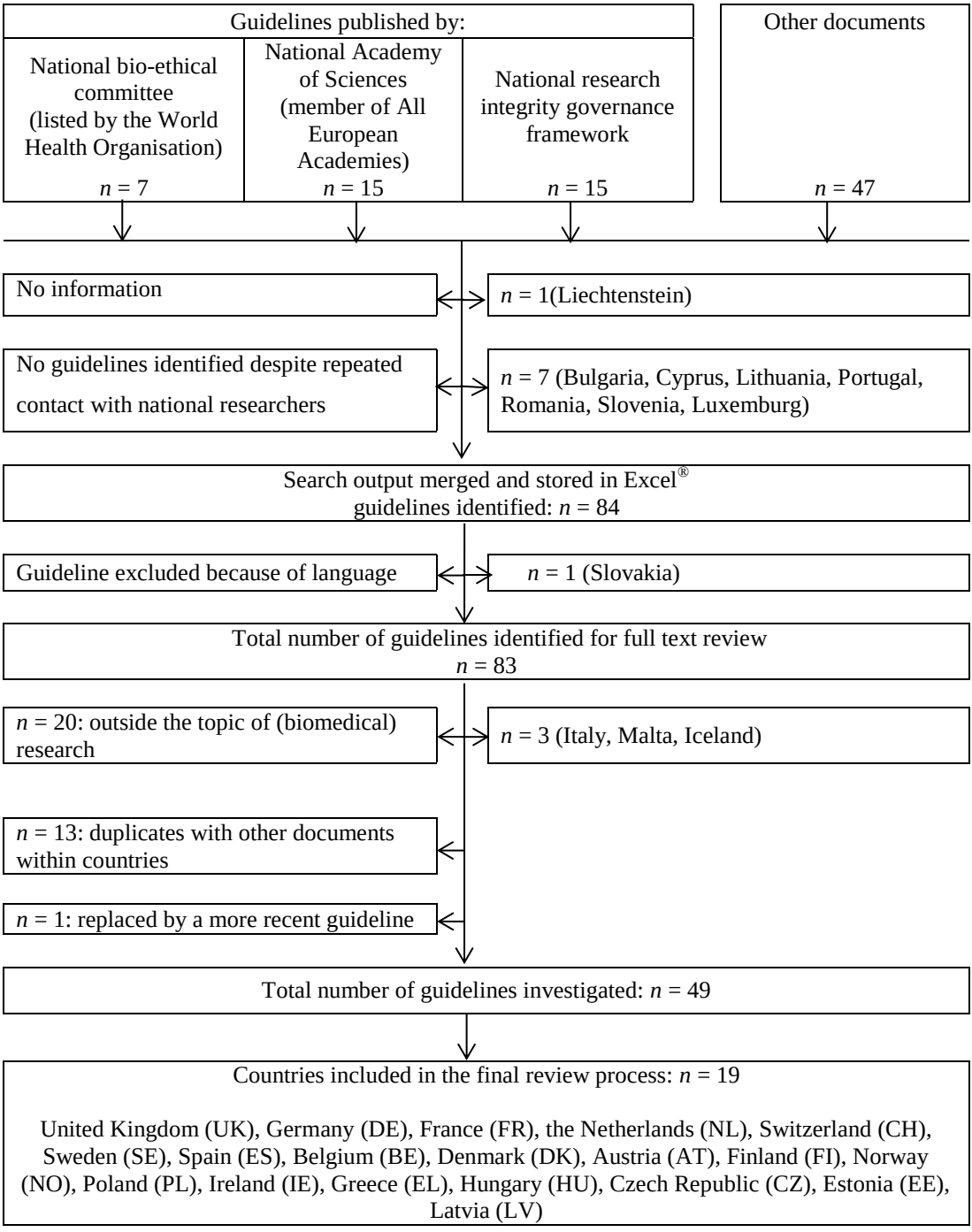

Table 1: Overview of the guidelines ranked according to the first date of publication within the country, guideline developer, year, title, word count (only English guidelines), and URL.

Country		Guideline developer	Year	Title	Word count	URL
LV		Latvian Academy of Sciences	1997	Scientist's Code of Ethics	2383	http://www.lzp.gov.lv/index.php?mylang=english
DE		German Research Foundation	1998	Recommendations of the Commission on Professional Self-Regulation in Science	16864	http://www.dfg.de/en/research_funding/legal_conditions/good_scientific_practice/index.html
FR	A	National Institute for Health and Medical Research	2000	Responding to Allegation of Scientific Misconduct: the Procedure at the French National Health and Medical Research Institute	3068	http://www.ncbi.nlm.nih.gov/pubmed/11273435
	B	National Centre for Scientific Research	2006	Scientific fraud at the National Centre for Scientific Research	442	http://www.cnrs.fr/fr/organisme/ethique/comets/avis.htm
	C	National Alliance for Life and Health Sciences	2011	Recommendations for the signing of scientific papers in the field of life sciences and health	929	http://www.inserm.fr/qu-est-ce-que-l-inserm/organigramme/comites/dis
NL	A	Royal Netherlands Academy of Arts and Sciences	2001	Note on Scientific Integrity	4632	http://www.knaw.nl/smartsite.dws?id=26101&lang=NL&pub=20011082
	B	Royal Netherlands Academy of Arts and Sciences and All European Academies	2003	Memorandum on Scientific Integrity	4776	http://www.allea.org/Pages/ALL/12/727.bGFuZz1FTkc.html
	C	Association of Universities in the Netherlands	2004	The Netherlands Code of Conduct for Scientific Practice. Principles of good scientific teaching and research (additions added in 2012)	3419	http://www.vsnu.nl/Universities/Quality-assurance/Code-of-conduct-for-scientific-practice-1.htm
PL	A	Polish Academy of Sciences	2001	Good manners in science. A set of principles and guidelines	7319	http://www.ken.pan.pl/images/stories/pliki/goodmanners.pdf
	B	Ministry of Science and Information Technology	2004	Good scientific research practice	5301	http://www.nauka.gov.pl/fileadmin/user_upload/37/23/37237/20080505_Good_practice_for_scientific_research_EN.pdf

EE		Estonian Academy of Sciences	2002	Code of Ethics for Estonian Scientists	1376	http://www.akadeemia.ee/en/documents/
FI	A	The National Advisory Board on Research Ethics	2002	Good scientific practice and procedures for handling misconduct and fraud in science	3980	http://www.tenk.fi/en/good_scientific_practice/printable.html
	B	The National Academy of Finland	2005	Guidelines on research ethics	2467	http://www.tenk.fi/en/links.html
UK	A	Wellcome Trust	2002	Guidelines on good research practice (updated in 2005)	1377	http://www.wellcome.ac.uk/About-us/Policy/Policy-and-position-statements/WTD002753.htm
	B	Wellcome Trust	2002	Statement on the handling of allegations of research misconduct (updated in 2005)	2453	http://www.wellcome.ac.uk/About-us/Policy/Policy-and-position-statements/WTD002756.htm
	C	Medical Research Council	2002	Good Research Practice	3904	http://www.mrc.ac.uk/Utilities/Documentrecord/index.htm?d=MRC002415
	D	Medical Research Council	2009	Scientific Misconduct Policy and Procedure	5124	http://www.mrc.ac.uk/Utilities/Documentrecord/index.htm?d=MRC005820
	E	UK Research Integrity Office	2008	Procedure for the investigation of misconduct in research	18759	http://www.ukrio.org/publications/
	F	UK Research Integrity Office	2009	Code of Practice for Research. Promoting good practice and preventing misconduct	10170	http://www.ukrio.org/publications/
	G	Universities UK	2012	The concordat to support research integrity	5795	http://www.universitiesuk.ac.uk/Publications/Pages/concordatosupportresearchintegrity.aspx
NO	A	Law	2006	Act of 30 June 2006 No. 56 on ethics and integrity in research	572	http://www.etikkom.no/In-English/Act-on-ethics-and-integrity-in-research/
	B	The National Committee for Research Ethics in Science and Technology	2008	Guidelines for research ethics in science and technology	5876	http://www.etikkom.no/Documents/English-publications/Guidelines%20for%20research%20ethics%20in%20science%20and%20technology%20(2008).pdf
CZ		Academy of Sciences of the Czech Republic	2006	Code of Ethics for Researchers of the Academy of Sciences of the Czech Republic (additions made in 2010)	1560	http://www.cas.cz/o_avcr/zakladni_informace/dokumenty/eticky_kodex.html

EL	A	Hellenic National Bioethics Commis-sion	2008	National Commission of Bioethics. Opinion on research ethics in the biological science	925	http://www.bioethics.gr/document.php?category_id=55&document_id=601
	B	Hellenic National Bioethics Commis-sion	2008	Report on research ethics in the biological sciences	4723	http://www.bioethics.gr/document.php?category_id=55&document_id=601
	C	Hellenic National Bioethics Commis-sion	2009	Template of Code of Research Ethics for Biological Sciences	1545	http://www.bioethics.gr/document.php?category_id=55&document_id=760
	D	Hellenic National Bioethics Commis-sion	2011	Opinion on conflict of interest in biomedical research	1289	http://www.bioethics.gr/document.php?category_id=55&document_id=1288
CH		Swiss Academies of Arts and Sciences	2008	Integrity in scientific research. Principles and procedures	6207	http://www.akademien-schweiz.ch/en/index/Portrait/Kommissionen-AG/Wissenschaftliche-Integritaet.html
BE		National Academy of Science	2009	Code of ethics for scientific research in Belgium	2650	http://www.kuleuven.be/cwi/english/Nationale%20code%20Belspo_en.pdf
DK	A	Danish Committees on Scientific Dishonesty	2009	Guidelines for Good Scientific Practice	14535	http://en.fi.dk/publications/2009/the-danish-committees-on-scientific-guidelines-for-good-scientific-practice/
	B	Law	2009	Consolidated Act No 306	1976	http://en.fi.dk/acts/executive-order-no.-306-of-20-april-2009
	C	Law	2010	Consolidated Act No 1064	6049	http://en.fi.dk/acts/act-on-the-research-advisory-system-etc/
HU		Hungarian Academy of Science	2010	Science Ethics Code of the Hungarian Academy of Sciences	10631	http://www.allea.org/Content/ALLEA/Scientific%20Integrity/ScienceEthicsCode-HAS.pdf
IE	A	Health Research Board	2002	Disclosure and Conflict of Interest	1117	http://www.hrb.ie/fileadmin/Staging/Documents/RSF/PEER/Policy_Docs/Good_practice_guidelines/Disclosure___Conflict_of_Interest_01.pdf
	B	Health Research Board	2008	HRB Guidelines for Host Institutions on Good Research Practice	2174	http://www.hrb.ie/fileadmin/Staging/Documents/RSF/PEER/Policy_Docs/Good_practice_guidelines/HRB_Guidelines_on_Good_Research_Practice-FINAL241007.pdf
	C	Health Research Board	2008	Policy for Dealing with Alleged Research Misconduct in Applications Made to the HRB	1092	http://www.hrb.ie/fileadmin/Staging/Documents/RSF/PEER/Policy_Docs/Good_practice_guidelines/Plagiarism_policy_-_FINAL241007.pdf

	D	Health Research Board	2008	HRB Guidelines for Host Institutions on the Handling of Allegations of Research Misconduct	2023	http://www.hrb.ie/fileadmin/Staging/Documents/RSF/PEER/Policy_Docs/Good_practice_guidelines/Allegations_of_misconduct-FINAL241007.pdf
	E	Irish Council for Bioethics	2010	Recommendations for promoting research integrity	31932	http://irishpatients.ie/news/wp-content/uploads/2012/04/Irish-Council-of-Bioethics-Research_Integrity_Document.pdf
	F	Royal Irish Academy	2010	Ensuring integrity in Irish research. A Discussion Document	6347	http://www.ria.ie/getmedia/28404e5c-4839-4408-9d40-e2a3770c775a/ensuring-integrity-in-irish-research.pdf.aspx
	G	Health Research Board	2010	Health Research Board Position Statement on Authorship	139	http://www.hrb.ie/uploads/media/HRB_Position_Statement_on_Authorship__May2010.pdf
	H	Health Research Board	2010	Details on how HRB Authorship position can be applied	1179	http://www.hrb.ie/uploads/media/Applying_Authorship_Position_May2010.pdf
AT	A	Austrian Agency for Research Integrity	2010	Rules of procedure for the investigation of alleged scientific misconduct	1714	http://www.oeawi.at/en/downloads.html
	B	Austrian Agency for Research Integrity	2010	Annex I to the Rules of Procedure of the Commission for Research Integrity: Guidelines for the investigation of alleged scientific misconduct	1012	http://www.oeawi.at/en/downloads.html
	C	Austrian Agency for Research Integrity	2011	Statement of the Commission for Research Integrity on Handling Cases of Plagiarism	512	http://www.oeawi.at/en/downloads.html
ES	A	Spanish Bioethics Committee	2010	Recommendations of the Spanish Bioethics Committee in Relation to the Drive and Implementation of Good Scientific Practice in Spain	2124	http://www.comitedebioetica.es/documentacion/index.php
	B	Spanish National Research Council	2011	Code of Good Scientific Practices of the Spanish National Research Council	5057	http://www.csic.es/web/guest/etica-en-la-investigacion
SE	A	The Swedish Research Council	2004	Guidelines: Expert Group for Investigation of Suspected Research Misconduct	2108	http://www.vr.se/inenglish/ethics/publications.4.325716ea11d7602a6d180008726.html
	B	The Swedish Research Council	2006	Conflict of interest policy	2425	http://www.vr.se/inenglish/ethics/publications.4.325716ea11d7602a6d180008726.html

	C	The Swedish Research Council	2011	Good research practice	57287	http://www.vr.se/inenglish/ethics/publications.4.325716ea11d7602a6d180008726.html

Table 2: Overview of the sources referred to by at least three different European guidelines. The countries are ranked horizontally according to how frequent their guidelines refer to the organisations listed vertically. The sources are ranked according to how frequent they are referred to by the guidelines of the countries.

Organisations referred to by the guidelines			**Guidelines referring to organisations**														
National organisations			IE	SE	UK	DE	PL	ES	FR	NL	CH	BE	EL	HU	CZ	DK	NO	AT
Country	***Organisation***	***URL***																
USA	Office of Research Integrity	http://www.ori.dhhs.gov/	x	x	x	x	x		x	x							x	x
	National Academy of Sciences	http://www.nasonline.org/	x			x	x			x								
	National Science Foundation	http://www.nsf.gov/	x	x		x												
UK	Medical Research Council	http://www.mrc.ac.uk/index.htm	x		x	x	x	x	x									
	Wellcome Trust	http://www.wellcome.ac.uk/																
	Committee on Publication Ethics	http://publicationethics.org/	x		x			x										
	Research Councils UK	http://www.rcuk.ac.uk/Pages/Home.aspx	x		x		x											
DE	German Research Foundation	http://www.dfg.de/en/index.jsp	x			x	x	x	x		x							
	Max Planck Society	http://www.mpg.de/en				x	x								x			

DK	Danish Committees on Scientific Dishonesty	http://en.fi.dk/councils-commissions/the- danish-committees-on-scientific-dishonesty	x	x	x	x	x											
International organisations																		
Organisation		***URL***																
European Science Foundation		http://www.esf.org/home.html	x	x	x		x	x		x	x	x		x				
International Committee of Medical Journal Editors		http://www.icmje.org/	x	x	x	x			x							x	x	
World Medical Association		http://www.wma.net/en/10home/index.html		x	x	x	x	x								x		
All European Academies		http://www.allea.org/Pages/ALL/4/731.bGFuZz1FTkc.htm	x								x		x	x	x			
Unesco		http://www.unesco.org/new/en/unesco/	x	x				x					x				x	
Economic Co-operation and Development		http://www.oecd.org/	x	x	x							x						
Council of Europe		http://hub.coe.int/	x	x									x					
European Commission		http://ec.europa.eu/index_en.htm	x	x								x	x					

Table 3: Principles of integrity and the elements and actions incorporated in the definitions of misconduct of the European guidelines. The countries are ranked horizontally, firstly the countries that only refer to certain principles, according to how frequently their guidelines incorporate the elements listed vertically.

	Countries																		
Positive approach: principles of integrity	CZ	BE	EL	LV	IE	AT	FR	DE	UK	NO	HU	EE	CH	SE	ES	NL	DK	FI	PL
Honesty	x		x	x	x	x		x	x	x	x	x		x	x				x
Reliability	x	x			x					x	x	x		x		x	x		x
Impartiality		x		x	x						x	x		x	x	x			
Objectivity	x		x	x	x					x	x	x		x	x				
Openness or open communication	x				x				x	x	x				x		x	x	
Responsibility for future generations through education or training and skills	x				x				x		x	x		x	x				
Independence		x								x		x		x	x	x			
Integrity	x		x						x	x		x						x	
Duty of care					x				x		x		x						
Verifiability	x	x			x							x				x			
Accountability	x								x	x									
Rigour		x							x										

Negative approach: actions or events incorporated in clear definitions of misconduct																			
Fabrication					x	x	x	x	x	x	x	x			x		x	x	x
Falsification					x	x	x	x	x	x		x		x	x	x	x	x	x
Plagiarism					x	x	x	x	x	x	x	x			x		x	x	x
Possible intention					x		x		x	x			x	x			x		
Deception					x				x				x	x		x			
Mismanagement of primary data and/or materials					x	x			x		x		x						
Violation of the law							x		x		x		x						
Violation of intellectual property						x							x			x			
Misrepresentation									x	x								x	
Fraud										x		x						x	
Fraudulent claims of authorship													x				x		
Misconduct regarding publication					x						x		x						
Facilitating misconduct									x				x						
Breach of confidence as a reviewer or supervisor								x				x							

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Chapter two: Heterogeneity in European research integrity guidance: relying on values or norms?

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authorship, peer review, publication ethics, questionable research, conflicts of interest, research integrity, research misconduct, prevention, science policy, guidance

Abstract

Similar forms of misconduct are perceived differently throughout Europe. There are no extensive surveys on the guidance on research integrity in the different countries of Europe. Therefore, we performed a systematic content analysis of (biomedical) research integrity guidance documents from all the countries of the European Economic Area. We showed that there is strong heterogeneity concerning research integrity guidance on crucial aspects, for example, the defining of research misconduct, at both an international and a national level. We also sought to explain why the guidance documents differ by distinguishing the approaches that underlie them. We distinguished a

value-based and a norm-based approach, as well as different perspectives on trust. The current confusing situation concerning research integrity guidance hampers international research and possibly wastes research funds. We risk talking past each other, if we do not take the distinction between these underlying approaches into account.

Introduction

Research misconduct makes the headlines of academic journals.[1-2] Research integrity and misconduct are important to all stakeholders within and outside science. These issues have been the subject of some recent research.[3-12] However, although almost a quarter of global research and development takes place in the EU,[13] and although European countries have not been spared from research misconduct scandals,[14] few studies have been published on research integrity in Europe.[15-16] Research integrity is also an issue beyond the scientific community, as evidenced by the research misconduct accusations aimed at prominent European politicians. Some of them have had to quit their office.[17-18]

Misconduct shakes science to its very foundation: It erodes the trust. Scientists need to trust each other for research to advance, and society needs to trust science to fund it.[19] However, research misconduct is defined heterogeneously throughout Europe. Most definitions include the concepts of fabrication (inventing data or cases),

falsification (intentionally misrepresenting data or results), and plagiarism (copying texts, data, or ideas without referring to the original source).[20] In addition, guidance documents include many principles that are considered to constitute research integrity, with honesty and reliability featuring most frequently, but the list of principles is long and diverse.[20]

Similar actions of research misconduct are approached differently. In the United States and the United Kingdom, researchers who falsified and fabricated data have been imprisoned.[21] However, the Dutch researcher Stapel, who's fraud became notorious, has only been sentenced to 120 hours of community service.[22] In Italy, there is currently a police investigation concerning a research fraud allegation, and it is advocated that researchers could at least learn from police methods for dealing with serious research misconduct allegations.[23] In other countries, the self-regulation of science is emphasized and research fraud is not considered to be a matter for the legal courts.

We conducted a comparative analysis of the guidance documents in the European economic area. We refer to these documents, which include laws and guidelines, as "guidelines". Previously, we distinguished two main approaches: guidelines utilizing a positive approach, emphasizing the principles of research integrity, and those using a negative approach, giving a definition of misconduct.[20] In the present article, we performed a systematic content analysis, and extracted and analyzed the data on all the aspects of research integrity and misconduct that were mentioned and discussed most frequently in

the guidelines. We also sought to understand why the guidelines differ.

Methods

We performed a comprehensive search for guidance documents concerning research integrity or misconduct, aimed at biomedical research or research in general, from all the countries belonging to the EU or the European Free Trade Association. The methods used for this search and an overview of these documents can be found in our previous publication.[20] Throughout this article, we use the word misconduct to identify infringements on scientific integrity.

We conducted a systematic content analysis of the received guidelines, for which we used a structured data-abstraction instrument.[24] First, we familiarized ourselves with the data by reading all received guidelines at least twice. Second, different (sub-)categories, representing the various elements present in the guidelines, were derived inductively by reading through all guidelines several times. We frequently discussed the content and representation of these classification categories. The different sub-categories are organized within two categories, representing the major approaches: research integrity and research misconduct. The topics covered by the sub-categories are the themes that were emphasized most frequently by the guidelines and are subject of heterogeneity. Table 1 gives an overview of all (sub-)categories used in the data-abstraction instrument. Table 2 gives an overview of the content and frequency of the themes discussed within

these (sub-) categories in the guidelines. We included the themes that featured at least in two different guidelines. The guidelines were analyzed, provided they were available in English, French, German, Dutch, or Italian. No statistical analyses were needed for this descriptive study.

Results

Retrieved guidelines

We sent more than 340 emails, and received replies from 30 out of the 31 target countries. Forty-nine guidelines, generated by 19 countries, were included for analysis. These 19 countries are responsible for 87% of all published scientific citable documents of the target population.[25] The 49 documents differed markedly not only in content but also in length: They ranged from 1 page to 129 pages.

Research integrity

Importance of research integrity

Almost 15% of the guidelines directly link research integrity to research quality (see Table 2: 1.1). An intrinsic part of research is publishing.[26-27] It is emphasized that authors should be responsible, but no agreement exists on what the authors are responsible for (see Table 2: 1.1). Originality and quality are considered more important than producing results quickly or publishing as much as possible,[28-29] especially as a criterion for academic career advancement, the alloca-

tion of resources, and the assessment of research performance.[30-31] Scientists should also inform the general public (see Table 2: 1.1), because public trust is crucial to all public funding of science.[27,29]

Threats toward research integrity

In the guidelines, two main threats to research integrity can be distinguished: the inaccurate preservation of data and conflicts of interest. Different perspectives emerge concerning the possible causes and the kinds of conflicts (see Table 2: 1.2). Conflicts of commitment are explicitly mentioned, caused by competing demands, such as teaching commitments, which can result in the neglect of research.[32-34] Several guidelines emphasize the management of conflicts of interest rather than their possible prevention (see Table 2: 1.2). An Irish guideline even states that conflicts of interest are unavoidable and not necessarily harmful.[32] Nevertheless, no agreement exists about when a researcher should withdraw from a research project. Some guidelines emphasize that reasonable doubt for a conflict of interest is a sufficient reason to withdraw.[35-36] However, one of the U.K. guidelines distinguishes less serious conflicts of interest from severe conflicts of interest. Only in the latter situation, researchers should withdraw from the project:

> "When addressing a conflict of interest, it must be decided whether it is of a type and severity that poses a risk of fatally compromising the validity or integrity of the research, in which case researchers and organizations should not proceed with the research, or whether it can be adequately addressed

> through declarations and/or special safeguards relating to the conduct and reporting of the research."[37]

Adequate preservation of primary data is essential for verifying the findings. Therefore, the inadequate preservation of primary data threatens research integrity. Several guidelines address the issue of the preservation of primary data, but a substantial variety exists concerning how long these data should be stored: ranging from no clear time indication, up to 10 years (see Table 2: 1.2). The loss of primary data could be a sign of research misconduct or gross negligence.[31]

Research misconduct

What constitutes research misconduct?

More than 60% of the guidelines give a clear definition of misconduct (see Table 2: 2.1). A relatively short definition of research misconduct is given by two of the Danish guidelines:

> "Scientific dishonesty shall mean: Falsification, fabrication, plagiarism and other serious violation of good scientific practice committed willfully or grossly negligent on planning, performance or reporting of research results."[38-39]

Various elements are included in the definitions of research misconduct of the other guidelines, such as the inadequate management of raw data or materials,[28-30,32,40-41] the violation of intellectual property of other scientists,[29-30,42-43] a breach of confidence as a reviewer or

supervisor,[31,44] and bringing personal influence to bear in decisions or evaluations.[28] Every definition of misconduct in the guidelines includes different elements, apart from the guidelines of Denmark and Norway. Although heterogeneity exists concerning these definitions, the concepts of fabrication, falsification, and plagiarism feature most prominently.[20] A Polish guideline, however, considers plagiarism to be less serious than fabrication and falsification: "(…) cases of misconduct related to falsification of research results are much more dangerous to science and its structures than plagiarism, which is easier to detect."[33]

Several guidelines consider the intention to deceive to be crucial in determining whether an action qualifies as misconduct (see Table 2: 2.1). However, one Swedish guideline underlines that the definition of research misconduct should encompass both intentional and unintentional actions.[27] It states that falsification covers all sorts of manipulations, which can be unintentional, whereas fabrication is intentional by definition. However, both falsification and fabrication are considered to be misconduct:

> "Manipulation of research—as opposed to cases of fabrication—can be the unintentional result of carelessness or ignorance, and it can be difficult to determine whether intentional misconduct has occurred."[27]

The guidelines explicitly condemn several malpractices concerning publication (see Table 2: 2.1). There is a general consensus that a

creative contribution is required to be qualified as an author (see Note).

Factors contributing to misconduct

The guidelines address several factors that contribute to misconduct. On one hand, there are personal motivations, such as the desire to be recognized and a desire to be successful.[33,45] On the other hand, the concept of competition is emphasized, which is approached from different angles (see Table 2: 2.2). There is the competition for ever more publications and the pressure to deliver results that can be applied as quickly as possible, [27-28,31-33,40,45-47] the competition for research funds and financial contracts,[27-28,32-33,40,46,48] and the competition concerning academic careers and the evaluation of scientific work.[28,31-32,40] However, competition is also considered to be important and even fruitful.[32,42-43]

Impact of misconduct

The direct impact of biomedical research on society is emphasized.[46,49] Misconduct in biomedical research can lead to bad medication and poorer treatment.[27-28] Most guidelines condemn misconduct because it damages trust and reputation. However, these concepts are approached from different perspectives (see Table 2: 2.3). The kind of trust that is endangered by research misconduct ranges from the trust between society and the scientific community,[27,32-34,40,44-45] the mutual trust between scientists,[27,31,33-34,42,43-45] to the trust of funding providers.[27,31] Damage toward reputation is also addressed from various

perspectives: the reputation of the individual researcher,[32,34,36-37,50-51] the institutions,[31-32,40,50] research projects,[37-51] and also the reputation of research in general.[29,32-33,40,50]

Detecting research misconduct

Various guidelines underline the possible identification of research misconduct through the peer-review process (see Table 2: 2.4). However, reservations are also voiced regarding its effectiveness: Peer review cannot detect every kind of research misconduct, because reviewers do not have the original data or the time to replicate the research,[31-32] and the review process, like the whole of science, depends on trust.

> "One reason the system has been challenged is a number of flagrant cases of peer reviewers abusing the trust which being given access to a colleague's work to assess it entails. Such abuses have included reviewers stealing ideas from submitted manuscripts, "sitting on" manuscripts for a long time to enable researchers in their own groups to publish their results first, or trying without just cause to prevent the publication of colleagues' work."[27]

Authors depend on confidentiality from the side of the reviewers and their goodwill in not plagiarizing their ideas, research results, or texts.[31] Because more and more manuscripts are submitted, it can also be difficult for journals to find willing and competent reviewers.[27] In addition, the reviewers are often competitors of the authors.[31]

There is unanimity that reviewers should act with the greatest integrity, objectivity, and thoroughness. However, various views are apparent about what part of the research should be submitted for peer review. Some limit peer review to the publication process,[31] while others extend it to the entire scientific process, including the evaluation of grant applications and during the ethics review of research projects.[37,51]

Dealing with allegations of misconduct

Clear and implemented procedures for handling research misconduct allegations are considered to promote research integrity.[42] It is explicitly stressed that research institutions should have adequate procedures in place for dealing with research misconduct allegations.[33,37,42-43,52-57] The employer of the researcher or the research institute has the prime responsibility for handling research misconduct allegations.[27-28,41-43,53,58-59]

Various elements concerning these procedures are emphasized by the guidelines (see Table 2: 2.5). The proper handling of research misconduct allegations is in the interest of the public and its trust in science, and it is crucial for all the stakeholders in science: the research community, the researchers, and the possible whistleblowers.[32,59]

Several guidelines underline that no punishment should be made until the misconduct is proven (see Table 2: 2.5). The National Academy of Finland, however, states, “In serious cases even the suspicion

of a violation will be grounds enough to make the decision not to award funding."[58]

Preventing misconduct

Various possible actions are mentioned to prevent misconduct. The research environment is important, but research integrity training features most regularly (see Table 2). A total prevention of misconduct is judged impossible.[31,33]

Discussion

Research integrity

As shown in the results, the inaccurate preservation of data possibly threatens research integrity. The European Code of Conduct for Research Integrity states that original data should be stored for "at least 5 years, and preferably 10 years".[60] The guideline of the Inter-Academy Council, however, refers to the requirements of the specific scientific discipline or the law.[61] Researchers can only elaborate on previous research, if the original data are carefully stored and shared with colleagues whenever possible.[61] However, there is a widespread reluctance to share published research data in several scientific disciplines,[62-63] also in biomedical research.[64-66] Even when authors signed the journal policy to share their data, many authors refuse to do so.[67-68]

Research misconduct

With the exception of the Swedish guidelines, as described above, the intention to deceive is considered to be a key element in defining research misconduct.[6] Despite the difficulty of determining whether an action was committed intentionally, the European Code of Conduct states that the response toward research misconduct should consider whether it was committed "intentionally, knowingly or recklessly".[60]

Plagiarism is often considered to be less serious than fabrication and falsification because it does not affect the scientific record.[6,69] The European Code for Research Integrity states that, unlike fabrication and falsification, plagiarism "is supposed to be more injurious to fellow scientists than to science as such".[60] Remarkably, only one of the guidelines analyzed also considers plagiarism to be less serious than fabrication and falsification.[33] Interestingly, this line of reasoning looks at the possible impact of actions on science. Following the same consequentialist logic, continued unintentional carelessness should be considered as reprehensible as fabrication because it can also severely damage science.

The Organisation for Economic Co-Operation and Development adds several factors that contribute to research misconduct: the negative sides of fragmentation, isolation, and specialization; and the difficulty of verifying results because some specialized instruments can only be operated by one researcher.[70]

The costs of research misconduct go far beyond monetary costs. Research misconduct threatens the progression and existence of science. The direct financial costs of "all of the allegations of mis-

conduct reported in the United States to the ORI (n = 217 cases) in their last reporting year ... would exceed $110 million".[71] More specifically in biomedical research, research misconduct can result in defective materials, threatening medical procedures, the wasting of resources, faulty policies, reputational damage to both the institution and other researchers, the victimization of patients or other researchers, and the loss of patient trust.[61,71-72] These consequences are direct and indirect infringements of the crucial principle of non-maleficence.[73] This demonstrates that research misconduct and integrity are not just a matter of social behavior, but are also of medical and ethical importance.

The peer-review system is also criticized in the scientific literature when it comes to detecting research misconduct.[74-76] The report of the InterAcademy Council states that peer review tends to be conservative, supportive of conventional research performed in prestigious research institutes, is susceptible to the subjectivity of the reviewers and is not designed primarily to detect unacceptable practices.[61]

Research integrity training is referred to most frequently to prevent research misconduct, although its effectiveness has been questioned.[3,77] Major issues concerning training remain unanswered, for example, who should be the trainees and who the trainers?[78]

The European continent is characterized by great cultural diversity, with countries having different legal systems and research traditions. Therefore, the guidelines also differ strongly in their origin. Some documents were published by ministries, others by national

organizations; some are laws, some are "only" guidelines (see Table 3).

Underlying approaches: Norms or values?

The current heterogeneity in the guidelines can be explained by using an ethical reflection that distinguishes the essence of values and norms.[79] Values are universal and guide people in what or how they ought to be. Values are translated into norms, which are embedded in a specific context: situation, time, and place. Norms are subject to change. They must be adhered to and generate clear rules. Values, however, feature on the level of education and role models.

This distinction can also be applied to the context of research. The value of verifiability, for example, is translated in certain norms, which can contradict one another. As stated earlier, the adequate preservation of raw data is essential for verifying the results. However, the value of verifiability is translated into different norms about how long these data should remain accessible. Some guidelines, for example, refer to the varying requirements of scientific disciplines.[28-29,80] Other guidelines give a very clear time limit: the raw data should be kept safe and unaltered for at least 3 years,[37,51] 5 years,[35,48,81] or up to 10 years.[30-31]

We stated earlier that we distinguished a positive and negative approach in the guidelines, focusing on research integrity and misconduct, respectively. Translating this into the ethical concepts of values and norms, we can distinguish a value-based and a norm-based approach, respectively. This distinction enables us to understand the

current regulatory diversity. It is difficult to give a universally accepted guidance on particular norms. Definitions of misconduct, for example, are based on norms. The unavoidable differences in research contexts will lead to diverse definitions. For example, the Hungarian guideline qualifies the unjustified restriction of the freedom of research as a form of misconduct, which is as serious as the fabrication of research data.[28] While, as demonstrated earlier, the Danish guidelines give a far more restricted definition of research misconduct.[38-39] A value-based approach however, relies on values, which are more universally accepted. Most researchers would agree to a list of certain values, such as honesty, that describe how a researcher should be. The Singapore Statement on Research Integrity, a global guideline published after the 2nd World Conference on Research Integrity, for example, does not give a clear definition of misconduct.[82] However, it does refer to several values, such as accountability and honesty.

The general regulatory approach taken by countries or organizations is founded on a value-based or norm-based approach. Countries with a more legalistic approach, for example, Denmark, include a clear definition of misconduct in law and therefore focus on certain norms. However, Belgium uses a more value-based approach. Based on our correspondence with the developers of the Belgian guideline, we found that they chose to create a moral code based on values, rather than a legal document. They stated that a law would be in need of constant adaptation. Some countries and guidelines combine both approaches.

The distinction between a value-based and norm-based approach is also applicable toward the possible prevention of research misconduct. The importance of the mentors is often stressed, because of their great impact on the daily research culture of a lab.[3,77] Research integrity training is judged to be ineffective if the mentors do not adhere to the content of these trainings. Mentors also give applied guidance, by prohibiting, allowing, or preferring certain practices. However, the greatest impact of the mentors is their guidance on the level of values. Mentors demonstrate what or how a researcher ought to be. Their example serves as guidance throughout the careers of their trainees. Because the context of research is bound to change, the norms will change as well. What is accepted in a certain time and place might be frowned upon in another. The values of the mentors have a longer and more stable impact, because they are translated into particular norms over and over again.

Whom or what do we trust?

The different approaches taken to stimulate research integrity, prevent and sanction research misconduct are also based on trust. We can distinguish two different approaches toward trust.[83] One approach emphasizes the trust in the integrity and responsibility of the researchers. It resembles to the value-based approach. We should be able to trust scientists and therefore, we should emphasize values and principles instead of rules and sanctions. For example, a Polish guideline states:

> "The ethics of humankind bind scientists in the same way as they do all other men and women, but the responsibility of the scientist is greater, because of a higher degree of consciousness, and also because scientists are assigned high rank in the social hierarchy and perceived as authorities in public life."[34]

Increasingly, we see a shift in research guidance and in society in general, toward a second approach, which focuses on the trust in control systems.[83] The trust in control systems resembles to the norm-based approaches. Two perspectives feature here concerning science: internal and external control systems. Within the internal control system, the scientific system itself is often viewed upon as self-correcting and trustworthy. Publications and grant applications are reviewed by peers; a hypothesis and science in general is always based on previous research. If research is fraudulent, certainly if it is ground breaking, it will be detected sooner or later.

The self-correcting ability of the scientific system has, however, been criticized.[12] Inherent to this approach is to consider science as an entity on itself, with its own rules and sanctions. Research misconduct is not considered to be an issue for the legal courts. Within the external control system, other forms of control and sanctions are emphasized, for example, regular data audits performed by researchers who are not directly affiliated with the project, which is common in pharmaceutical companies; the possible intervention of the police in research misconduct allegations;[23] and legal sanctions for people who committed research fraud. According to this approach, researchers can learn from police investigations.[23] Therefore, it implies that research

misconduct can be a matter for the legal courts. This reasoning goes against the other perspective that makes a clear distinction between the world of science, which cannot be understood by laypeople, and the legal court:

> "A natural response to a police investigation is that outsiders could never understand the academic system well enough to sit in judgement. Really? Police forces worldwide routinely deal with financial and computer crimes, the details of which can seem equally impenetrable. Understanding what a western blot is and why it shouldn't be tampered with are obvious challenges for a non-scientist—as is understanding the mysteries of the academic world and the role of peer-reviewed publications within it. But the police know a thing or two about conducting an investigation. And any external inquiry has a distinct advantage: it cannot be hindered by the intrinsic threat of conflict of interest that comes when any community sits in judgement on its own members."[23]

Conclusion

We risk talking past each other, if we do not consider the different perspectives on trust and if we do not take the distinction between the value- and norm-based approaches into account. Although they are not mutually exclusive, the norm-based and value-based approaches have a different focus and purpose. A norm-based guidance generates clear and applied rules, whereas a value-based approach focuses on principles and role models. Research is becoming ever more interdisciplinary and international,[84] which enables a more value-based approach because of its more universal nature. Because research always takes

place in a specific context, there is nonetheless also a need for clear norms, and therefore for a norm-based approach. The defining of research misconduct, for example, gives researchers a clear framework, which helps them in balancing their research conduct. In addition, the vast amount of guidelines is not helpful, due to the differences between them, sometimes even within one country.

Research agenda

Researchers currently need to balance their research conduct in a context of heterogeneous standards and guidelines concerning research integrity and research misconduct. This will not stimulate research integrity. More research is needed to investigate the current research integrity guidance. It is important to further document, describe, and analyze how different institutions handle research misconduct allegations and how they try to prevent misconduct. It can give us an insight into whether and how the guidance on a national level are implemented in universities and research centers, for example. In addition, more empirical research is needed to document and analyze the perspectives of the researchers themselves. What are their perspectives and attitudes concerning research integrity and misconduct?

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Note

The Latvian guideline, however, is ambiguous on the criterion of who can qualify as an (co-)author. Although it emphasizes creativity, it states the following: "Only on the author's (or authors') own initiative, by tradition, the leader of the scientific school (or the scientific advisor) can be mentioned as a co-author, putting his surname as the last one. No automatic co-authorship is admissible as regard to the administrative leaders of the institution, chair or other structural unit".[36]

Table 1: (Sub-)categories of data-abstraction instrument.

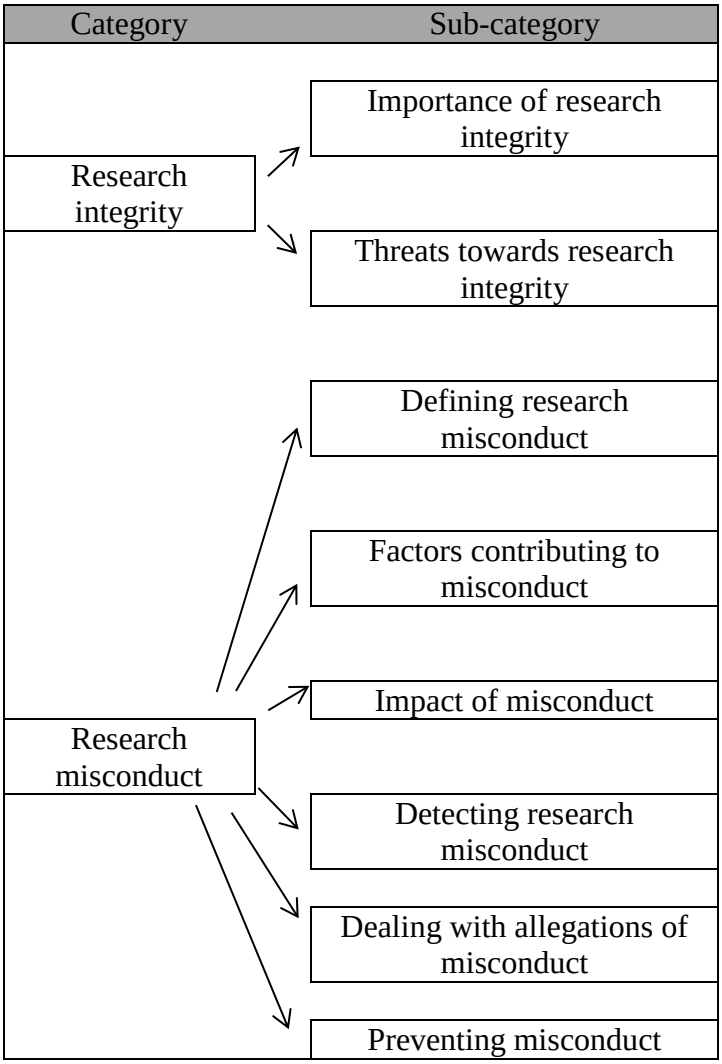

Table 2: Overview of the Themes Discussed, Within the Distinguished (Sub)-Categories, by at Least Two Guidelines.

Themes discussed within the (sub-) categories by of the guidelines			Guidelines (n = 49)
1. Research integrity	1.1	Importance of research integrity	
		Stress the link between research integrity and research quality	7
		Responsibility of authors	
		Authors are responsible for the published content	12
		Authors are responsible for the integrity of the entire project	2
		Scientists must inform the general public	5
	1.2	Threats towards research integrity	
		Conflicts of interest	19
		Causes of conflicts of interest	
		Financial interests	6
		External pressure	5
		Interest of third parties or personal relationships	4
		Personal conflicts of interest	2
		Various kinds of conflicts	
		Distinguish potential and apparent conflicts	10
		Distinguish personal and institutional conflicts	3
		Conflicts of commitments	3
		Emphasizing the management of conflicts of interest by focusing on transparency	11
		Preservation of data	12
		Varying requirements of scientific disciplines	3
		Data preservation for at least three years	2
		Data preservation for at least five years	3
		Data preservation for at least ten years	2
2. Research misconduct	2.1	Misconduct	
		Give clear definition of misconduct	31

		Inclusion of possible intention, negligence or deceit in definition of misconduct	16
		Malpractices concerning publication and authorship	
		Honorary or gift authorship	16
		Selective publication of desirable results	15
		Ghost authorship	3
	2.2	Factors contributing to misconduct	
		Competition	10
		For ever more publications and applicable results	9
		For research funds and financial contracts	7
		For academic careers and scientific evaluation	4
		Personal motivations (desire to be successful or to be recognized)	2
	2.3	Impact of misconduct	
		Trust is foundational to science	15
		Misconduct damages trust	11
		Damage to the mutual trust between scientists	8
		Damage to the trust between society and science	7
		Damage to the trust of funding providers	2
		Damage to reputation	10
		Damage to the reputation of the individual researcher	6
		Damage to the reputation of research in general	5
		Damage to the reputation of research institutions	4
		Damage to the reputation of research projects	2
	2.4	Detecting research misconduct	
		Possible detection of misconduct trough peer review	4
	2.5	Dealing with allegations of misconduct	
		Institutions should have adequate procedures	11

		Employer/institution has first responsibility for handling allegations	8
		Procedure should be rapid and confidential	8
		Reputation of both the whistle-blower and the person accused must be protected	4
		Whistle-blowers can also be motivated by dishonest intentions	4
		No punishment should be made until the misconduct is proven	4
		All parties should be heard during the handling of research misconduct allegations	3
	2.6	Preventing misconduct	
		Emphasizing research integrity training	22
		Emphasizing research environment and daily practice	5

Table 3: Overview of the origins of the guidelines.

Origin of the Guidelines	Guidelines (n = 49)
Published by Ministries	1
Laws	3
National Bio-Ethical Committees (listed by the World Health Organisation)	6
National Research Integrity Governance Frameworks	8
National Academies of Sciences (member of All European Academies)	11
National Research Organizations	20

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Phase two:

Empirical studies

Chapter one: Differing perceptions concerning research integrity between universities and industry: a qualitative study

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Keywords

research integrity, research misconduct, industry, university

Abstract

Despite the ever increasing collaboration between industry and universities, the previous empirical studies on research integrity and misconduct excluded participants of biomedical industry. Hence, there is a lack of empirical data on how research managers and biomedical researchers active in industry perceive the issues of research integrity and misconduct, and whether or not their perspectives differ from those of researchers and research managers active in universities. If various standards concerning research integrity and misconduct are upheld between industry and universities, this might undermine research collaborations. Therefore we performed a qualitative study by conducting 22 semi-structured interviews in order to investigate and compare the perspectives and attitudes concerning the issues of research

integrity and misconduct of research managers and biomedical researchers active in industry and universities. Our study showed clear discrepancies between both groups. Diverse strategies in order to manage research misconduct and to stimulate research integrity were observed. Different definitions of research misconduct were given, indicating that similar actions are judged heterogeneously. There were also differences at an individual level, whether the interviewees were active in industry or universities. Overall, the management of research integrity proves to be a difficult exercise, due to many diverse perspectives on several essential elements connected to research integrity and misconduct. A management policy that is not in line with the vision of the biomedical researchers and research managers is at risk of being inefficient.

Introduction

Most empirical data on research integrity have been obtained from studies among researchers active within universities.[1-8] These studies have shown that research misconduct occurs within (biomedical) research. Admitted or observed actions among researchers range from so-called questionable research practices, such as inadequate supervision of researchers, to serious forms of research misconduct, for example falsification of research data. It is noteworthy that certain researchers indicate that questionable research practices are admitted to and observed rather frequently, and, hence, they present a greater threat to the research community than serious forms of research misconduct, which occur less frequently.[2]

In addition, providing a commonly accepted definition of research integrity is challenging. Generally a list of principles or values is given to define research integrity. However, of the various guidance documents collected in a previous study,[9] not one document gave an identical list of values. Nonetheless, our analysis showed that the following elements were referred to most often: honesty, reliability, impartiality, objectivity and openness or open communication. Several values or principles are also generally shared throughout the international research community. For example, the Singapore Statement on Research Integrity, an international guideline published after the 2nd World Conference on Research Integrity, underlines values such as accountability and honesty.[10] In the USA, the NIH provides the following description of research integrity:

> "Research integrity includes: the use of honest and verifiable methods in proposing, performing, and evaluating research; reporting research results with particular attention to adherence to rules, regulations, guidelines; and following commonly accepted professional codes or norms."[11]

The NIH also refers to the work of dr. Steneck:

> "Shared values in scientific research: honesty: convey information truthfully and honoring commitments; accuracy: report findings precisely and take care to avoid errors; efficiency: use resources wisely and avoid waste; objectivity: let the facts speak for themselves and avoid improper bias."[12]

Although a lot of biomedical research is done within industry, we found no published research on research integrity among biomedical researchers working in industry. In addition, research collaborations between industry and universities are widespread, and encouraged. The lack of (published) empirical data on research integrity performed in for-profit biomedical environments is remarkable, especially since the pharmaceutical industry has faced accusations of research misconduct, but has also spoken out on the topic of research integrity.[13-15]

Commercial pressures and financial conflicts of interests of researchers within universities who work with or are sponsored by industry have been frequently invoked, implicitly or explicitly, to underlay or even cause unethical behaviour.[16-17] However, it is not known whether or not researchers hold different views about research integrity and misconduct depending on whether they work in industry or within universities. Therefore, we conducted a qualitative study consisting of a narrative and inductive content analysis of 22 semi-structured interviews. The main research question of our qualitative research was: do biomedical researchers and research managers hold different views on research integrity or misconduct depending on whether they are active within industry compared to universities? The interviewees were biomedical researchers and managers working either in universities or industry. Although various (international) biomedical companies have codes of conduct,[18-19] they mainly or exclusively concern Good Clinical Practices or business ethics. These perspectives were not included in our study because they did not focus on research integrity and misconduct.

Methods

We interviewed six directors of the doctoral schools of Belgian universities, eight persons working in spin-off companies and eight persons working in large multinational drug companies (> 10,000 employees worldwide), all active in Belgium, from June until December 2013. In both the spin-off companies and the multinational companies, half the interviewees were mainly engaged in doing research, while the other half were senior managers. The main characteristics of the interviewees are presented in Table 1. Within universities, we included directors of the doctoral schools of biomedical sciences of the Belgian universities because they occupy a unique position by being themselves engaged in research and management, and also responsible for the training of many PhD students. Interviewees from spin-offs and international companies were recruited by first contacting key persons in the companies and then by "snowballing", because it was not possible to obtain lists of personnel and select individual employees directly.

A qualitative approach was used because it could reveal interesting outcomes that could not be obtained by a survey. Due to the sensitivity of the topic and the restrictive policies of private companies, semi-structured interviews were preferred over focus groups. We conducted semi-structured interviews, until data saturation was reached (n = 22).[20] We elaborated an interview guide (see Supplementary appendix) based on our previous research findings.[9,21] All the interviews but one were conducted at the interviewee's workplace, in

Dutch, English or French (i.e. some quotes have been translated into English for this paper). The interviews lasted about one hour on average (median: 56 minutes; 25th-75th percentile: 45 minutes – 75 minutes; range 27 minutes – 90 minutes). They were tape recorded and transcribed by the same interviewer (SG).

We analyzed the transcripts using systematic inductive content analysis, by using a structured data abstraction instrument to define themes and subthemes.[20] All the interviews were read several times, coded by one person (SG), first on printed paper, and afterwards again using the software NVivo 10. The accuracy and applicability of the codes developed were checked by the two co-authors (KD, BN) for three representative interviews and consensus was reached. In this paper, we include several (translated) quotes of the interviews. To give the background of the interviewee for each quote, we applied the following labels: 'C' for international companies; 'S' for spin-offs; 'U' for universities, with every interviewee being given an individual anonymous label (e.g. C1, S2, etc.).

Results

Research misconduct

Identical actions were judged heterogeneously between universities, spin-offs, and international companies, and sometimes even within one company. Overall, fabrication of data, falsification and plagiarism were judged to be the gravest offences. However, within spin-offs and international companies plagiarism was considered a far less serious

form of misconduct than fabrication and falsification. All the interviewees considered an action to be misconduct when it was committed with the intention to deceive. Despite this it was often stressed within industry that even unintentional carelessness in research is serious, because it is a form of inadequacy.

When asked to score 14 actions (see Figure 1), senior managers within international companies appeared to be stricter in judging actions to be misconduct, than active researchers within the same companies; persons from spin-off companies tended to be less strict than those from the other two groups. The range of opinions was broadest among university research directors.

Several interviewees considered that misconduct is mainly committed by juniors, because of naivety or a lack of knowledge. Others, however, stated that different forms of misconduct were committed by persons with different seniority and responsibilities. They experienced in their own organizations that more serious forms of misconduct were committed by senior researchers, whereas minor forms were committed by juniors. The majority stated that when a senior commits research misconduct, this is likely to be more intentional and, therefore, more serious.

Research misconduct was considered to be harmful for a variety of reasons (see Table 2). Within international companies, strong emphasis was placed on the possible harmful effects towards patients and the economic costs of not being able to reproduce data. One interviewee within universities stated that misconduct might become the normal practice, because of its frequency. Misconduct leads to a waste of

money, research resources and time of other researchers and organizations.

Various elements were considered to influence research misconduct (see Table 3). Firstly, systemic elements were mentioned: several forms of pressure, competition, and a general focus on quantity rather than quality. For example, if the supervisors or mentors are only interested in confirmations of their own hypotheses, they generate a culture where the goals justify the means and where the risk for research misconduct is very high. A form of pressure evoked by interviewees, regardless of where they worked, consisted of uncertainty about their job position. Interviewees active within universities also strongly emphasized the pressure to publish ever more papers. Some interviewees within spin-offs indicated that they had specifically chosen a research career within industry, because this enabled them to focus on their actual research instead of enlarging their list of publications. Secondly, more personal motivations and characteristics were mentioned to influence research misconduct, such as ambition, greed, the need of recognition, and frustration. Finally, interviewees often stipulated that qualitative research methods are more susceptible to research misconduct than quantitative methods, because the latter are more objective, rigorous and, therefore, more difficult to manipulate.

> "Quantitative research is easier to report objectively. If you report misleadingly, then this is really intentional. With qualitative research, the boundary is much vaguer. But if you make a fault intentionally, that is

> equally bad, but in an unintentional way you might do this more quickly." (S_4)

Procedures for dealing with research misconduct?

Interviewees within universities, and within most spin-offs, stated that no formal procedures existed in their organization to deal with research misconduct allegations. This contrasts strongly with senior managers within international companies, who underlined that such procedures did exist in their organizations. They stressed that whistle-blowers were protected, for example by the possibility of making anonymous accusations. Nonetheless, researchers of the same international companies generally proved to be unfamiliar with or even totally ignorant about these procedures. Making anonymous complaints was not possible according to the interviewees within universities. Additionally, specifically within universities, there was a concern to mix allegations of research misconduct with personal conflicts.

> "It is difficult when a colleague commits fraud. Is that colleague a friend of yours, or a competitor? That makes a big difference, of course. A competitor will get the impression that you want to attack him and then it no longer matters whether he has committed fraud or not, then it is an attack. If he is a friend of yours, then you can say, I will talk to him personally. Then you can say: 'This looks strange, is there something wrong?'" (U_6)

Only within some international companies, initiatives had been taken to create a network of confidential advisors whom people can consult. Someone could, for example, get advice on the proper

practice or on how to deal with a suspicion of research misconduct. No such systems were in place in universities and spin-offs. Additionally, interviewees from international companies and spin-offs regularly stressed that everyone who witnesses a form of research misconduct, is obligated to act on it: either to a commission or talk it over with the researcher conducting the misconduct. Such obligation was not mentioned within universities.

Strategies to prevent research misconduct

Interviewees of the different groups consistently emphasized "training" and "raising awareness" in order to prevent misconduct. All interviewees active within international companies had followed some training covering integrity. They stated that everyone who is involved with research within international companies, regardless of their level of management, is obligated to follow such training. However, these trainings were broad, also covering financial fraud, animal welfare, and sexual harassment, for example. Of those working in spin-offs, only two younger interviewees had previously received some training during their training at the university. In sharp contrast, none of the interviewees within universities – who were all directors of doctoral schools – had themselves ever received any formal training on research integrity, although training programs for PhD students were in place or under construction in some institutions.

Despite the stated importance of awareness, all of the interviewees but one, were unfamiliar with the national Belgian guideline on research integrity. Even those who considered themselves responsible

for research integrity or those who taught research integrity within their organization, did not know this guideline. Some were unable to define crucial concepts, such as '*conflict of interest*', and '*fabrication of data*'. The interviewees were also divided on whether or not guidelines were effective, and if so, whether they should be binding or not. However, it was consistently stressed that guidelines should not be too long.

Interviewees of international companies believed good data management could prevent research misconduct and they stated that within their companies elaborated data management systems existed. However, this was not the case for smaller spin-offs and universities, where interviewees were in general unfamiliar with data management systems. One interviewee within universities admitted that he stored his data as long as they fitted in his small office. Nonetheless, within universities, several claimed to have taken individual initiatives to optimize the research data storage. Additionally, it was remarked that data storage is expensive and can therefore not be compulsory for every research project.

Throughout the interviews, sharing research data was often considered to contribute to research integrity, by creating more transparency. Nevertheless, interviewees were very restrictive towards sharing their own data. Firstly, because sharing was considered as giving away the commercial or competitive advantage. Secondly, sharing negative data could possibly harm the reputation of the research organization, lab or individual researchers. Thirdly, it was advocated, mainly within universities, that because the researcher or the research group received a

grant or scholarship, they own the data and therefore did not have to share them. Yet, managers of international companies stated that they can and do share their data on request.

> "There was a time of protectionism of the own domain and we were forced to safeguard this. Now (…) everyone who works permanently within the company has access to all the data and can see everything." (C_3)

Interviewees of the international companies, and mainly the senior managers, were convinced that (their) elaborated rules and regulations detect and prevent research misconduct. They relied heavily on rigorous control systems, e.g. strict reporting procedures and audits. One senior manager stated that universities should evolve towards a similar system. In sharp contrast, interviewees within universities emphasized that there are already too many regulations. More rules would hamper the necessary creativity and be too complex and time consuming. One interviewee within universities even spoke of a "rule-sickness" that paralyses science. Despite the reliance of senior managers within international companies on rules and control systems, the researchers from the same companies commented on recent misconduct cases within their institution, which the system could not trace:

> "I worked on a study and afterwards it turned out that indeed for example the diary cards, to check whether people have all kinds of adverse effects, that one of the investigators just filled these out in the evening at home in her kitchen. (…) If she had not divorced her husband, and if that divorce

> had not turned into a fight, then that husband would have never told this to us. And we have absolutely no way of knowing if such a woman is falsifying data in her kitchen. So, no, I do not think all errors will be detected." (C_4)

Also a linguistic approach of the interviews demonstrates a more repressive approach in industry compared to universities. For example, the word 'sanction' (including its verbs, pronouns, etc.) was explicitly and spontaneously mentioned by 6 of the 8 interviewees within large companies and by 4 of the 8 interviewees within spin-offs, compared to only 1 of the 6 interviewees in universities.

Finally, throughout all the interviews, the crucial importance of the common or "day-to-day" culture was stressed. A culture that solely focuses on quickly getting positive results was considered to stimulate research misconduct.

Research integrity

Research integrity was regarded, explicitly or implicitly, in many different ways. Some considered it essentially a matter of the overall personal integrity of the researcher. Others, however, stated that research integrity covered many elements: the motives to start a research project, the adhered principles when conducting and publishing research, the data management, and the return to the community. The principles of honesty, objectivity, truthfulness, transparency, and non-maleficence were emphasized most strongly. Additionally, some interviewees of international companies and spin-offs considered research integrity to be the same as research quality or even the very essence of

research. Interestingly, six of the 22 interviewees did not (or could not) define integrity, but they spontaneously related research integrity to its negative counterpart, i.e. questionable research practices or research misconduct, such as falsifying and fabricating research data, and plagiarism.

Mentorship

Previous research has demonstrated the impact of mentors on research practice.[22-23] However, who is perceived as a mentor? In universities, the promoter, or a post-doc researcher, were generally considered to be mentors, whereas interviewees from international companies and spin-offs frequently had no mentor within the organization, or they referred to distant inspirational figures (such as the founder of the company). Nevertheless, when mentors were evoked, they were consistently perceived to have (had) a crucial impact. Interestingly, mentors or senior researchers were also held responsible for stimulating research misconduct or questionable research practices. A senior researcher stated the following:

> "I mean, for experiments with mice, we always submit an application to the ethics committee. But sometimes you do an experiment which is not mentioned very explicitly in the application. However, then you say: 'it was in line with the spirit of the application'. If it is in line with the spirit of the application, I think I even do it." (U_1)

Some stressed that the physical presence of the mentor in the lab is essential, because PhD students or employees need to be able to

confide and consult with him or her regularly. However, both within universities and industry in general, seniors are required to take on other responsibilities, and can therefore be less present in the lab.

> "(sighing, long silence) Alright, if you are a PI that still works in the lab, you are a very young PI who has no administration and who does not write big grant proposals and network proposals. Therefore, for a big PI, this is absolutely unrealistic. (...) my colleagues, who are full professors, they are not even one minute in their lab." (U_6)

Trustworthiness of research

Overall, reputation was strongly considered as a criterion for trustworthiness of research: reputation of the researchers, the research institutions, or the scientific journal. Also the used methodology, the level of independence and the linguistic quality of the article were mentioned. Additionally, reproducibility was often discussed. Within large companies, non-reproduced research was considered worthless. Within universities, however, some posited that reproducibility of research does not tell anything about the integrity, or even the objectivity of the research.

Finally, transparency was generally strongly valued, mostly as a way to make reproducibility possible. Most interviewees of spin-offs emphasized that because of the smaller size of their organization, there was a culture of general transparency, which stimulated research integrity. "Everyone always knows what happens." (S_1) Otherwise, participants of larger companies stressed that spin-offs and smaller companies rely strongly on a limited number of research projects.

Therefore, in their perspective, spin-offs are more directly dependent on the positive outcomes of these projects, which might question the trustworthiness of their research and thereby endanger research integrity.

Perception from industry towards universities and vice versa of participants

Overall, a strong mutual distrust was apparent between international companies and spin-offs on the one hand, and universities, on the other. The frequent problems with non-reproducibility of research findings were often evoked by members of international companies and spin-offs to justify their limited trust in research conducted within universities, as published in peer reviewed journals. “We see that in three to four times out of ten, we cannot reproduce the data.” (C_1)

On the other hand, interviewees within universities often underlined that in general industry is only concerned with financial profit and is inclined to solely present data and findings in a positive or commercially favourable perspective. Interestingly, interviewees from international companies and spin-offs implied that some academic labs had become small companies themselves, with publications instead of drugs being the intended output. “We do not sell publications. Our income is independent of publications.” (S_4) In addition, researchers active within industry often felt despised by researchers within universities:

> "Sometimes if you work for a pharmaceutical company as a medical doctor, you are considered by other medical doctors that do not work for a pharmaceutical company, as the enemy, the one who moved to the other side." (C_4)

Mainly within international companies, the benefits for the patients as a motivation to conduct research were strongly emphasized, in contrast to the more fundamental, disinterested research conducted within universities. Interviewees within universities, however, regularly mentioned that researchers within industry in general receive more financial benefits and higher wages, and one interviewee added that people within industry worked fewer hours.

> "Within universities (…) it is the intellectual development, purely the intellectual development. (…) It is certainly not for the material conditions in which you work, because even though some universities are more or less well organized, the equipment we have cannot be compared with what we can find within private companies, no more are the salaries. They have the motivation of the convenience of work, because in general, I know several of them, they work fewer hours than people who work within universities." (U_2)

Discussion

Universities and industry employ various strategies to stimulate research integrity or prevent research misconduct. This heterogeneity might hamper inter-institutional research, as well as further collaborations between industry and universities. Our previous research

also demonstrated strong international and even national diversity concerning research integrity guidance.[9,21] The current diversity in policies can conceivably result in a situation where, for example, a researcher has to abide by different standards concerning research integrity depending on his or her (international) collaborating partners.

A qualitative approach was used because no similar research has previously been published and it could reveal interesting empirical outcomes. Due to the sensitivity of the topic and the restrictive policies of private companies, semi-structured interviews were preferred over focus groups. Our qualitative study clearly documents that managers and researchers within international companies uphold different attitudes and perspectives towards research integrity and misconduct. In general, the senior managers of international companies had a more optimistic view of the state of integrity in their company than the researchers active in the same companies. As shown above, these researchers in lower hierarchical positions pointed out that several forms of misconduct are still possible and lapses do occur. Additionally, the active researchers also defined misconduct less rigorously. Research integrity policies seem to be elaborated and trusted by managers, who however do not always seem to consider the perspectives and attitudes of the researchers themselves.

Guidelines and regulations concerning research integrity and misconduct were also often believed to be non-existent, or when they did exist, they were not known or not adhered to. For example, despite the abundant trust in regulations within industry, none of the interviewees within international companies or spin-offs knew that the national

Belgian research integrity guideline even existed. Additionally, within universities, notwithstanding the existence of publically accessible requirements and guidelines concerning authorship, various interviewees stated that there are no clear rules on who qualifies as an author.[24] Hence, they considered authorship as a matter of negotiation and compromise. Young researchers within international companies or spin-offs, who had left their universities, regularly testified of authorship being unrightfully granted to or claimed by people, for political or strategic reasons.

In general, the interviewees of both universities and industry were hesitant during the interviews, with long silences or sighing. This general hesitation, combined with the lack of knowledge of the guidelines, and the diverse definitions given, if any, of research misconduct and integrity, question the impact of the current research integrity policies.

Impact of commercialization

The commercialization of research has been claimed to threaten scientific integrity.[16-17,25] In our interviews, researchers at universities often indicated that 'real' researchers are not driven by financial or commercial motives, in contrast to researchers active within industry. Yet, interviewees from both international companies and spin-offs strongly felt wronged and left out from the debate on research integrity. They were convinced of expending greater efforts to stimulate research integrity than universities, by for example providing obligatory training, making rigorous procedures and having elaborate

data management requirements. Nevertheless, our analysis suggests that certainly managers within international companies were more inclined to give ethically or socially desirable answers during the interviews. Whether procedures, rules and trainings really stimulate integrity and effectively prevent misconduct remains unclear.

It might be interesting, however, to see where universities and industry can learn from each other in order to stimulate research integrity. For example, the creation of a network of confidential advisors whom people can consult with questions on research integrity or misconduct, such as exists within some international companies, might contribute to an honest and open debate within universities. By putting the emphasis solely or mainly on the procedures to deal with complaints of research misconduct and the possible sanctions, problems that can be solved and systems that can be optimized, might be ignored in fear of retribution.

As mentioned earlier, international companies organize obligatory research integrity training for all who are involved with research. The elaboration of such trainings concurs with national guidance documents on research integrity of the European Economic Area, which strongly support research integrity training.[9,21] Nevertheless, within universities only some institutions had, or were in the process of installing, research integrity training, and these were singularly aimed at young PhD researchers only. However, it has been shown that the impact of research integrity training depends, among other elements, on the characteristics of the trainees and the trainers.[26] Therefore, a

thorough reflection concerning research integrity training and whether or not they should be compulsory, is vital.

Our analysis has demonstrated that directors of doctoral schools within universities were unfamiliar with the national guideline and gave diverse definitions of research misconduct. As shown by previous research, mentors have a strong influence on the daily research culture impact on the practice of research.[22-23] When, for example, mentors deviate from the application approved by a research ethics committee, they teach their (junior) researchers that such a conduct is acceptable. Mentors give clear guidance through their actions, their sanctions, but also through what they do not do, tolerate or even reward. Consequently, there is clearly a need within universities to also include senior researchers in research integrity training, just as is the case in international companies. Even more so if senior researchers are indeed more inclined to commit serious forms of research misconduct, as several interviewees testified.

Despite the lack of earlier published empirical data comparing the viewpoints of biomedical researchers and research managers within industry and universities, it is interesting to note that for the revision of the European Code of Conduct for Research Integrity, there was a "extensive consultation among major stakeholders in European research, both public and private."[27] Initiatives such as this might help to stimulate research integrity guidance, agreed upon and shared by both the universities and industry. However, in order to fully achieve an agreed upon and shared research integrity policy, such guidance documents need to rely on empirical data which provide an overview

of the perspectives of biomedical researchers and research managers themselves.

Our study has a number of limitations. First, for the selection of interviewees from spin-offs and international companies we needed to use the method of "snowballing", as described in our method section. We cannot exclude a selection bias. It is possible that we were referred to those participants that adhered most rigorously to research integrity. Another possibility is that we were referred to those participants that had a clear opinion on these issues, hence other biomedical researchers or research managers possibly did not worry so much about research integrity or misconduct. Second our research does not explain why we found differences in the perspectives on research integrity and misconduct between industry and academia. Third, in our study we focused on analyzing possible differences and similarities based on the 22 interviews conducted. The data should not be taken on face value, but we nevertheless believe that they are suggestive of trends that should be verified by appropriate quantitative research. Based on the analysis of these interviews, as well as on our previous research findings, we later conducted a large computer-based survey of biomedical researchers and research managers.[28] Combining this qualitative and quantitative approach provided a reliable method to investigate the perspectives on research integrity and misconduct within biomedical research as well as possible differences between universities and industry. Fourth, we realize that the interviews were conducted several years ago. More recently, the perspectives on research integrity and misconduct might have evolved. However, we

again underline that this qualitative study has been followed by a survey.[28] Fifth, we tried to select participants who would be able to provide the viewpoints of the daily research perspectives on the one hand, and management on the other hand. Due to the structure of industry, we had to include senior managers for the management perspective and biomedical researchers for the daily research perspective. Within universities we were able to combine both perspectives by including directors of the doctoral schools of biomedical sciences, as explained in the method section. However, this difference in characteristics of the participants might form a bias when comparing industry to universities. Finally, this study has been performed in the limited context of Belgium. Nevertheless, we included international biomedical companies active all over the world. Additionally, the participants had various international backgrounds and there are no reasons to assume that the Belgian situation would greatly differ from other industrialized Western countries. Because of its central location in Europa, many biomedical companies are active in Belgium.

Our empirical analysis is the first of its kind, considering and comparing the perspectives and attitudes of industry and universities. We advocate such research is needed in order to really talk with, rather than past each other. Additionally, we believe that a research integrity policy demands a clear overview and analysis of the perspectives and attitudes towards research misconduct and integrity, and motivations for conducting research of all stakeholders. Due attention must also be given to the involvement of the different stakeholders

and the appropriate communication. At least, they have to know it exists in order to be able to abide by it, let aside agree on it.

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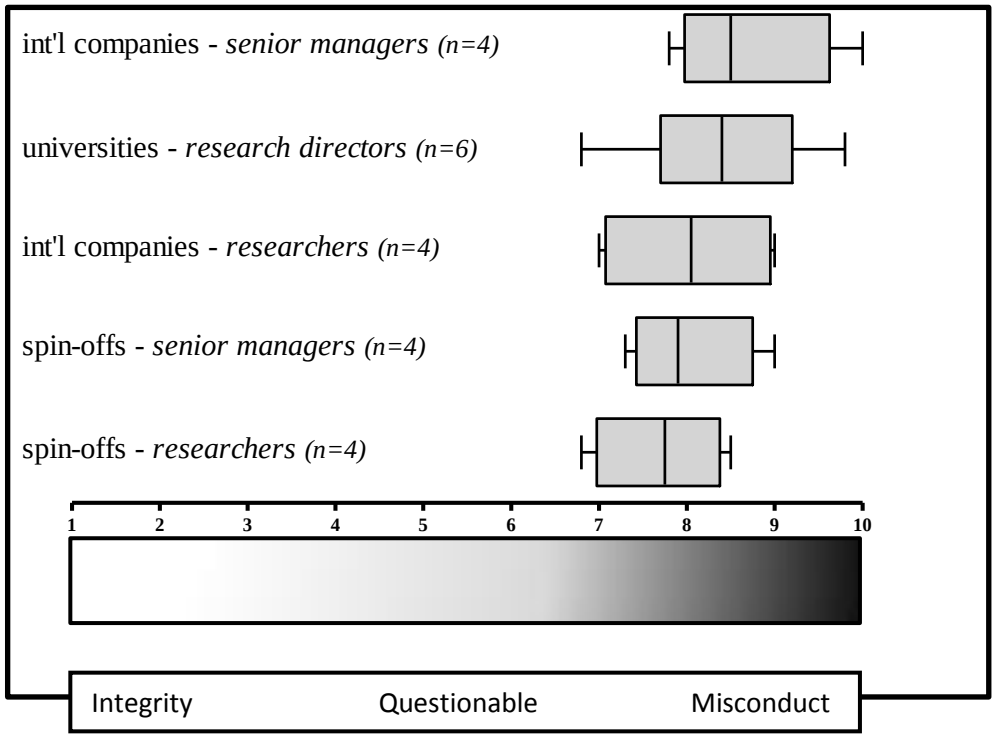
Conflict of interest

The authors declare that they have no conflict of interest.

Figure 1: Interviewees' perspectives on research misconduct.



Legend: 22 interviewees were asked to score 14 actions, extracted from previous research,[5,6] on a scale from 1 (integrity) to 10 (misconduct). The 14 actions were: fabricating data; falsifying data; plagiarism; fraud; breaking the law; not or barely dealing with research misconduct allegations; facilitating research misconduct; improper storage of original research data; breach of confidence by a supervisor; breach of confidence by a reviewer; unrightfully claiming authorship; incomplete and therefore misleading reporting of used methodology; carelessness in research; acting unintentionally. The box plots represent the distribution of the median scores of each subject (with 25th and 75th percentiles and extreme values). One subject declined to score 4 items, five subjects declined to score one item; these undetermined scores were ignored when calculating an individual's median score.

Table 1: Characteristics of the 22 interviewees.

Age	
> 30 years	*4*
30-40 years	*5*
41-50 years	*7*
51-60 years	*3*
61-70 years	*3*
Country of birth	
Belgium	*15*
Other (the Netherlands, Germany, Greece, Mexico)	*7*
Gender	
Men	*15*
Women	*7*
Highest obtained degrees	
PhD	*15*
Master (or other)	*7*
Country where highest degree was obtained	
Belgium	*19*
Other (United Kingdom; the Netherlands; Germany)	*3*
Function	
International companies (3 companies)	
Higher management	*4*
Researchers with middle/low management	*4*
Spin-offs (6 companies)	
Higher management	*4*
Researchers with middle/low management	*4*
Universities (4 Dutch speaking ; 2 French speaking)	
Director of doctoral school biomedical sciences (or equivalent)	*6*

Table 2: Reasons given why misconduct can be harmful. The numbers represent the amount of interviewees who explicitly mentioned the given reasons.

	Academics	Spin-offs	International companies
Damages the scientific record and slows down science	4	5	3
Dangerous for patients	2	2	7
Loss of time and money	1	1	4
Damages the trust			
between scientists	2	2	2
between organizations		1	2
Damages the reputation			
of the institution	2		2
of a research group or lab	1	1	
of a research field		1	
of research as a whole	1	1	1
of a journal	1		
Wrong decisions are made based on fraudulent research	1	1	
Normative shift: unacceptable practices become acceptable	1		
Risking to lose talented researchers			1

Table 3: Factors given that were deemed to stimulate research misconduct**.** The numbers represent the amount of interviewees who explicitly mentioned the factors.

	Academics	Spin-offs	International companies
Systemic factors			
Competition	3	1	1
Pressure			
Pressure to publish	4	3	3
Pressure to perform	1	1	6
Pressure to achieve grants	1		2
Pressure resulting from a conflict of interest			1
Pressure to provide funds for the employees		1	
Focus on quantity rather than quality		1	1
Financial motives			1
Personal factors			
Ambition or greed	3	1	3
Money			4
General lazyness		1	2
Frustration		2	
Personal character	1	1	
Vanity		1	1
Need of recognition		1	1
Methodological factors			
Qualitative research methods are more sensitive to fraud than quantitative	1	1	1

Supplementary appendix

As a supplementary appendix, we provide the interview guide and the scale that was used during the interviews. Interviewees were asked to score the actions (listed on p. 125) by placing them on the scale (p. 124), ranging from good research practice until research misconduct.

Interview guide

Your position

First of all, I would like to get a better image of your current position.

- What is your age?
- Where were you born?
- What is your nationality?
- In what country did you obtain your highest degree?
- What is your highest degree (research domain)?
- What is your current function in your organization?
- For how long have you held your current position in your organization?
- How many years have you (already) performed research?
- What percentage of you work represents actual research?

Part I

- Could you, on a scale from 1 to 10 (with 1 being always individual and 10 always in group) indicate if your research activities are mainly performed individually or in group? Is so, how does this work? How big are the groups?
- Could you, on a scale from 1 to 10 (with 1 as very bad and 10 as very good) describe how you feel in your research context?

Part II

- What are your thoughts about the concept of "research integrity within biomedical research"?
- How would you rank the following practices on the continuum?
- Which criteria do you use to classify an action or an event as misconduct or good research practice?
- Where do you stand on the intentional character of fraud? ("honest mistakes")?
- Should we look more at the impact of certain actions?
- Are there any practices of research misconduct which you recognize in your research domain?
- What is/are the reasons why a researcher would perform research misconduct?
- Do you think research misconduct is more common today than in the past?

- Do you think research misconduct can be/is harmful? Why?

Part III

A. Daily research practice

- What are the criteria to consider a colleague in your domain to be successful?
- What do you consider to be the motivation of researchers to do research?
- Are original research data shared with colleagues (of the same institution)?
- Is there general data storage? If so, how long are the data stored? How does one have access to this data?
- Is your research subjected to Good Laboratory Practices?
- Who is responsible for stimulating/guarding the integrity of research in your organization?
- Who is responsible when things go wrong in your organization (researchers themselves, the first author, all the authors, managers, etc)?
- Is publishing important for you? Why?
- Do you think that there can be a cooperation between industry and the academic sector? If so, how should this work?

B. Management

- Is there in your research domain/organization/country a guideline concerning research integrity or fraud?
- How does your organization deal with allegations of research misconduct?
- Have you ever received any kind of formal (or informal) training concerning good research practices?
- What constitutes a conflict of interest in you domain?
- What are the important criteria concerning the trustworthiness of research (on a structural level)?
- Who do you consider to be a mentor concerning your research?
- Does your mentor have a strong impact on your research or your scientific attitude?
- Do your colleagues or other people in your research environment have a strong impact on your research or your scientific attitude?

C. Prevention of research misconduct and stimulation of research integrity

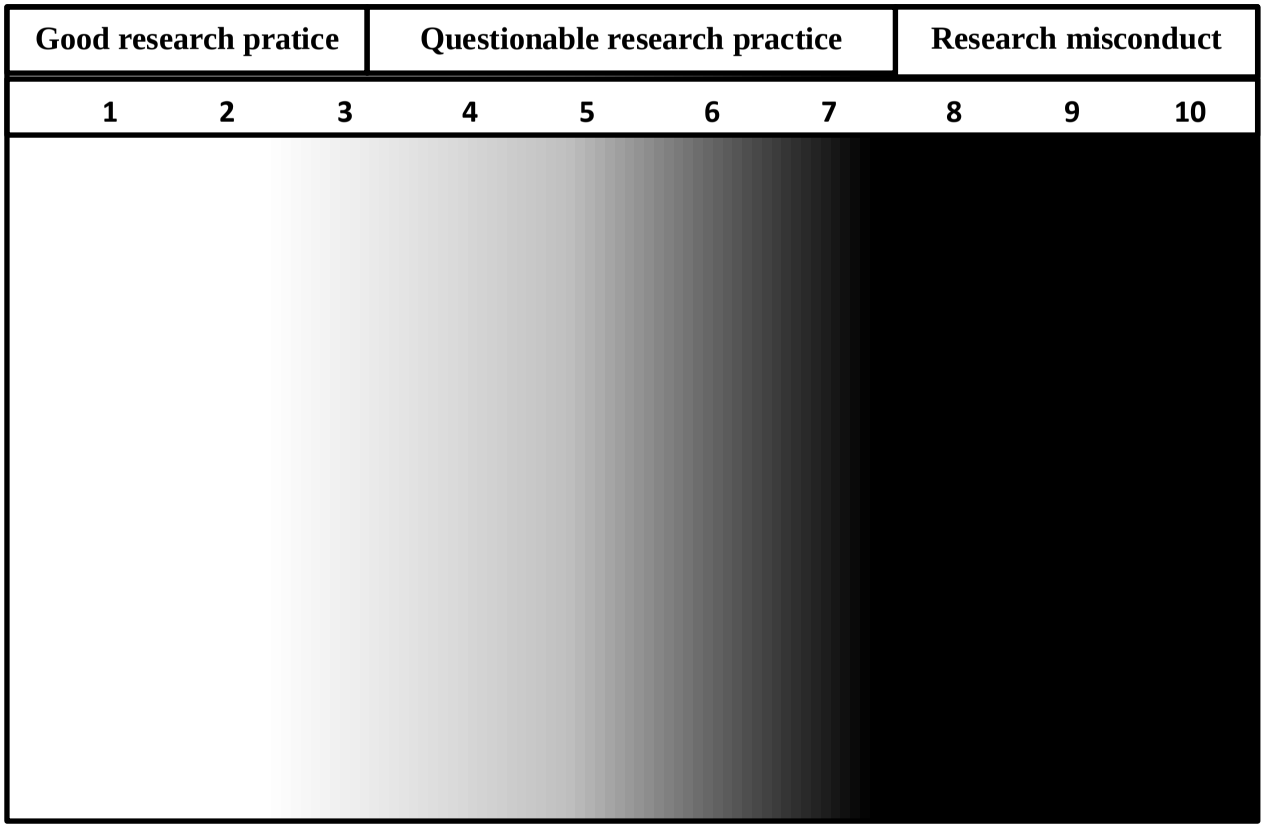
- What do you consider to be crucial for preventing research misconduct?
- Do you think guidelines can or have to play a role in this?
- Is prevention possible?

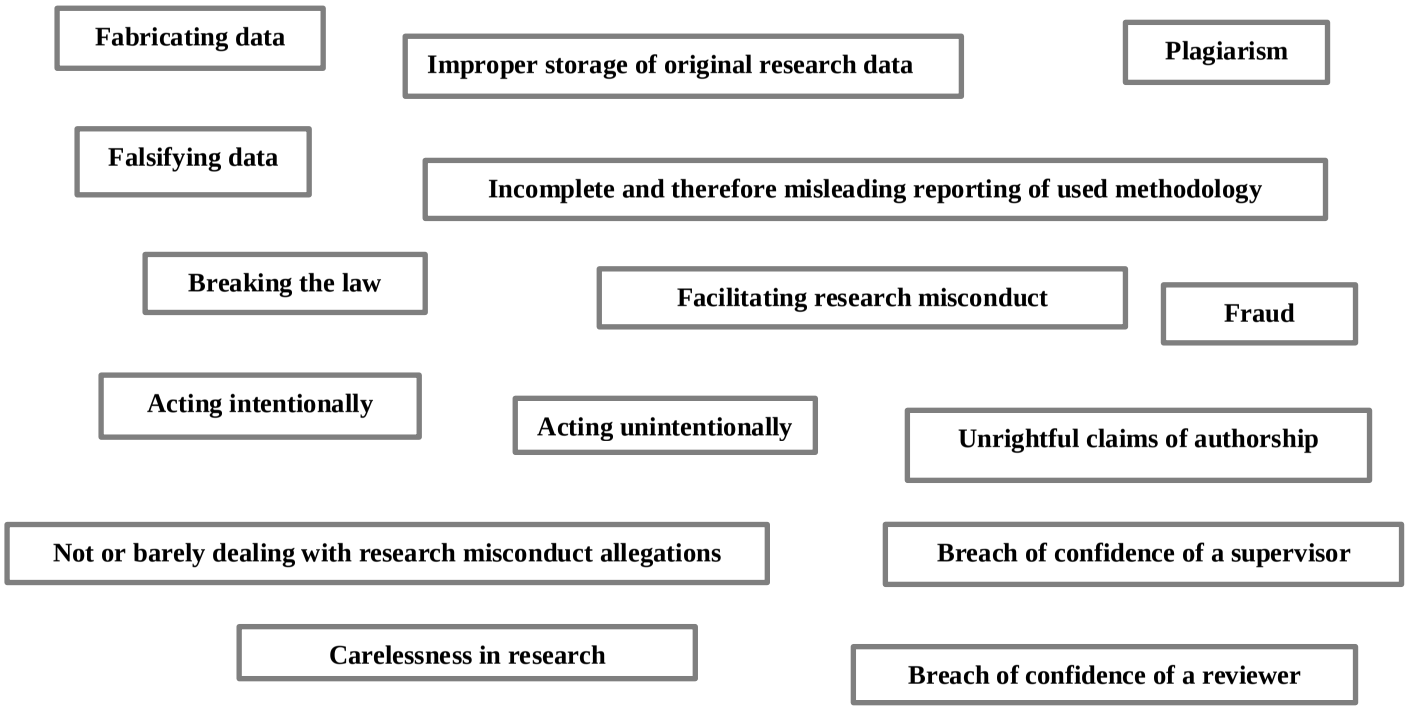
- Do you consider science to be self-correcting?
- Will fraud or misconduct be discovered (eventually)?
- Does peer review effectively detect research misconduct?
- What is crucial in the stimulation of research integrity?

End

- Would you like to add something?
- Do you have any questions?
- Thank you.

Scale used during the interviews.




Fabricating data
Improper storage of original research data
Plagiarism
Falsifying data
Incomplete and therefore misleading reporting of used methodology
Breaking the law
Facilitating research misconduct
Fraud
Acting intentionally
Acting unintentionally
Unrightful claims of authorship
Not or barely dealing with research misconduct allegations
Breach of confidence of a supervisor
Carelessness in research
Breach of confidence of a reviewer

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Chapter two: Scientists still behaving badly? A survey within industry and universities

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Keywords

research integrity, research misconduct, industry, university

Abstract

Little is known about research misconduct within industry and how it compares to universities, even though a lot of biomedical research is performed by - or in collaboration with - commercial entities. Therefore, we sent an e-mail invitation to participate in an anonymous computer-based survey to all university researchers having received a biomedical research grant or scholarship from one of the two national academic research funders of Belgium between 2010 and 2014, and to researchers working in large biomedical companies or spin-offs in Belgium. The validated survey included questions about various types of research misconduct committed by respondents themselves and observed among their colleagues in the last three years. Prevalences of misconduct were compared between university and industry respondents using binary logistic regression models, with adjustments for relevant personal characteristics, and with significance being

accepted for $p<0.01$. The survey was sent to 1766 people within universities and an estimated 255 people from industry. Response rates were 43% (767/1766) and 48% (123/255), and usable information was available for 617 and 100 respondents, respectively. In general, research misconduct was less likely to be reported by industry respondents compared to university respondents. Significant differences were apparent for one admitted action (gift authorship) and three observed actions (plagiarism, gift authorship, and circumventing animal-subjects research requirements), always with lower prevalences for industry compared to universities, except for plagiarism. This survey, based on anonymous self-report, shows that research misconduct occurs to a substantial degree among biomedical researchers from both industry and universities.

Introduction

In 2005, a Nature article revealed that a substantial portion of scientists ‘‘behaved badly’’ and admitted various forms of scientific misbehavior.[1] This has been confirmed in numerous other studies of university researchers.[2-3] Academic researchers often claim that the pharmaceutical industry badly influences biomedical research practice or conducts fraudulent research.[4-8] Industry has indeed been found guilty of various forms of research misconduct,[9-10] and it has been shown that ‘‘positive’’ outcomes are more likely for industry funded research than for research funded by other sources.[11] Conversely, researchers from biomedical companies have complained that research published in peer reviewed academic journals is often irreproducible, implicitly accusing academic researchers of unethical practices.[12]

Rosenbaum has argued that the academic distrust towards industry is based on emotional rather than rational reasons.[7-8] However, her claim does not rest on much objective evidence, since little or no empirical studies have compared practices and attitudes with regard to research integrity and misconduct between industry and universities. We conducted a large computer-based survey of biomedical researchers and research managers - using a methodology used by others[1] - to test the hypothesis that the experiences and views on research integrity and misconduct differ between those working in industry and those working in universities. By means of this survey, it was determined how often biomedical researchers from universities and industry reported to have committed or observed various forms of research misconduct and the prevalences of reported misbehavior were compared between university-based and industry-based respondents. The relation between the prevalence of observed or admitted research misconduct and several possible predictors, such as age, gender, having obtained a doctoral degree (PhD), level of management, having received mentoring and research integrity training were also investigated.

Methods

We adapted a survey that was used in previous research conducted in the USA,[1] on the basis of our review of the research integrity guidance documents in Europe, and the analysis of 22 semi-structured interviews conducted with biomedical researchers and research managers active in universities or industry in Belgium.[13-15] In our survey, we

asked whether the respondents had, in the past three years, committed (themselves) or observed their colleagues committing 22 actions of research misconduct (see Table 1). These responses will be labelled ‘admitted’ and ‘observed’, respectively, in the further text.

Throughout our article we will not only consider fabrication, falsification and plagiarism to be misconduct, but 22 actions in total, based on our previous research and the USA survey. We grouped these 22 actions of research misconduct into six categories, in line with the previous USA study: ‘data misconduct’, ‘methods misconduct’, ‘credit misconduct’, ‘policy misconduct’, ‘cutting corners misconduct’, and ‘outside influence misconduct’.[16] We also asked respondents to indicate the kinds of mentoring, as well as the kind and the amount of research integrity training, received. Finally, questions were asked about personal characteristics including gender, age, and level of management (without possibilities of identification). A detailed overview of the questions can be found in Table 2.

All instructions and questions were in English (most, if not all, biomedical researchers in Belgium may be expected to have a good working knowledge of English). Opportunities for adding free text were available for several questions. The national Privacy Commission and the ‘Social and Societal Ethics Committee’ of the University of Leuven gave a positive advice for our protocol. We guaranteed anonymity to the individual participants and their organizations. We sent out our online survey from February until May 2015. Up to four reminder e-mails were sent.

Population and sample

The target population of our survey consisted of biomedical researchers and research managers active within universities or industry in Belgium. We e-mailed a link to our survey to all individuals who had received a grant or scholarship from the two national academic research funders of Belgium (Research Foundation– Flanders; Fonds de la Recherche Scientifique), in 2010, 2011, 2012, 2013 or 2014, for doing biomedical research in a university.[17-18] Hereby all the 10 Belgian universities were included.

To contact the relevant biomedical companies, we went through several phases. Firstly, we searched and contacted regional and national databases, such as Pharma.be,[19] FlandersBio,[20] Biowin,[21] BrusselsLifetech.[22] In addition, we listed the biomedical spin-offs of all the Belgian universities, and asked the universities whether this list was relevant. Secondly, we contacted each company by phone or e-mail, to verify whether they conducted research (other than marketing or clinical trials) in Belgium. If so, we asked them if they would be willing to let their biomedical researchers and research managers participate in our survey. Of the 50 companies conducting biomedical research in Belgium (from small spin-offs to international corporations), 27 accepted to participate either by giving us the e-mail addresses of their eligible employees (11 companies) or by sending an invitation to participate in the survey to their eligible employees (16 companies).

Validity

To calculate the content validity index, we consulted three experts: the chairman of the Flemish Commission for Scientific Integrity; the director of a doctoral school of one of the Belgian French speaking universities; the person responsible for research ethics at a major international biomedical company active in Belgium. They ranked all the individual questions on a 4-point Likert scale, ranging from 'not relevant' to 'highly relevant'. We revised or removed questions that all three experts did not consider relevant. Afterwards, the revised questions were reviewed again by all three experts. Our survey had a content validity index (S-CVI/Ave) of 0.98.[23]

We also conducted a pilot study by sending the survey to the 15 Steering Committee members (active in industry or universities) of the Belgian Society of Toxicology and Ecotoxicology. We obtained a response rate of 53% for this pilot. The survey scored well on face-validity and user-friendliness.

Statistical analyses

Fisher's exact tests and Mann–Whitney-U tests were used to compare variables between respondents active in universities and industry. Associations between admitted and observed behavior were evaluated with Spearman correlations. Binary logistic regression models were used to evaluate possible determinants for reporting research misconduct. Analyses were performed for each action separately, for all actions ('presence' being defined as replying 'yes' for at least one of the 22 actions), and per category of misconduct ('presence' being

defined as replying ‘yes’ to at least one of the actions belonging to the specific category). To handle missing information in the considered predictors, a multivariate imputation was performed using the fully conditional specification (FCS) approach.[24] In this approach, for each of the variables with a missing value, a regression model was specified using all other predictors and all outcome variables as covariates.

Depending on the variable, a linear regression, binary logistic or ordinal logistic regression model was used. The process was iterated (one iteration consists of one cycle through all variables) until convergence to the multivariate distribution was obtained. Ten complete datasets were created and a multivariable logistic regression model was fitted in each of the datasets. The results of the ten analyses performed on the ten completed datasets were combined using Rubin’s rule.[25] Two versions of the multivariable model were considered. First, the difference between university and industry was evaluated after correction for age, gender, holding a PhD, having obtained a degree abroad, and level of management (model A). Second, having received mentoring and research integrity training were added (model B). The predictors considered in the latter model were determined based on a backward stepwise selection procedure with 0.157 as the critical level for the p value. The model reduction was performed on a stacked dataset consisting of the multiple imputed data, using a weighting scheme to account for the fraction of missing data in each covariate.[26] The odds ratios (with 95% confidence intervals) reported in the text, refer to the result of multivariable model B. Given the multitude of performed tests, only p values smaller than 0.01 (instead

of the classical 0.05) were considered significant. All analyses have been performed using SAS software, version 9.4 of the SAS System for Windows.

Results

As summarized in Fig. 1, the survey was sent by e-mail to 1766 people within universities, and to an estimated 255 people from industry. Although the exact denominator was unknown for participants from industry, we estimated the survey was delivered to 255 people, based on fragmentary information received from the companies about the numbers of e-mails sent out to their employees. A total of 890 persons responded to the survey (767 working in universities and 123 working in industry) thus yielding response rates of 43% (767/1766) and 48% (123/255), respectively. For some respondents, no information (N = 165) or only incomplete information (N = 8) was available on reported behavior (observed combined with admitted), leaving a final analysis sample of 717 subjects (617 in universities and 100 in industry).

Respondents from universities and industry did not differ strongly in terms of gender or being holder of a PhD (Table 2). Respondents from industry were almost twice as likely to have obtained a degree outside Belgium than those in universities. Because university respondents included nearly seven times more young people (age 20–29) than industry, the proportions of senior versus junior management level differed between the two groups.

Overall, respondents from universities had received more mentoring from their promoters, supervisors, etc. This difference was significant for having received assistance in obtaining financial support. Additionally, more respondents from industry indicated they had followed research integrity training compared to universities, with a significant difference for online research integrity training.

The prevalence of reporting both admitted and observed research misconduct was generally higher within universities than within industry: 71% of respondents from universities compared to 61% of respondents from industry admitted at least one of the 22 actions. Similarly, 93% of the respondents from universities and 84% of those from industry reportedly observed at least one of the 22 actions being done by their colleagues. However, this latter difference did not reach significance in multivariable model B (see Tables 3 and 4).

We observed a positive relation between having observed and admitting research misconduct. Participants who observed more actions also admitted to more actions themselves, among respondents from either universities (rho= 0.63, $p<0.001$) or industry (rho= 0.65, $p<0.001$).

Significant differences were apparent for three observed misconduct actions (plagiarism, gift authorship, and circumventing animal-subjects research requirements) and one admitted misconduct action (gift authorship), with lower prevalences being found for industry compared to universities, except for plagiarism (see Tables 3 and 4). Gift authorship was reported frequently in both contexts: it was observed by 50% of respondents from industry and by 76% of

respondents from universities; it was admitted within industry by 25% of the respondents, compared to 42% within universities, thus making gift authorship about half less likely to occur within industry compared to universities. In contrast, plagiarism was twice more likely observed and three times more likely admitted by respondents from industry compared to those from universities.

Fewer than half of the respondents (47% in industry and 22% in universities; $p<0.001$; not shown in Tables) were confident that fraud would always be detected in their organization. Within industry 79%, against 52% within universities, were willing to report a case of research misconduct ($p<0.001$; not shown in Tables). Many academics did not know whether they would report a case (38%) or stated they would not do it (10%). The main reasons why one would not report a case, were the lack of protection of whistleblowers for participants in industry and the possible harm of relationships with colleagues for universities.

When the separate actions were grouped in six categories, as done by the previous USA research,[16] then 'policy misconduct', either observed or committed, stands out as being less likely to be reported by industry than academia. The other categories were also less frequently reported by industry respondents, however without reaching our stringent level of significance ($p<0.01$) (see Table 5).

Tables 6 and 7 (see Supplementary appendix) provide an overview of the relations between possible predictors and the reporting of research misconduct for each of the six categories taken separately. A positive relation was present between level of management and

observing forms of ‘outside influence misconduct’. Respondents with a higher and middle management position observed more ‘method misconduct’ being done by their colleagues. Respondents holding a PhD observed and admitted to more forms of ‘credit misconduct’, than respondents without a PhD. Respondents who had completed a degree outside Belgium admitted fewer forms of ‘cutting corner misconduct’. There were no significant relations with age.

Respondents who reported having received an informal kind of research integrity training, generally observed and admitted more forms of misconduct. For example, respondents who indicated they had received research integrity training by “workshops, conferences, roundtable discussions” observed ($p = 0.013$) and admitted ($p = 0.007$) to more ‘outside influence misconduct’. In contrast, formal research integrity training resulted in a lower reporting of various forms of research misconduct. Respondents who indicated they had received research integrity training by “a section on research integrity within other courses in your field” admitted to significantly fewer forms of ‘cutting corner misconduct’ ($p = 0.001$).

Equally, receiving various forms of mentoring generally related with reporting fewer forms of research misconduct. Respondents who had received “instruction in the details of good research practice” observed significantly fewer forms of data misconduct ($p = 0.002$).

In our survey we did not ask about the nationality of the respondents, due to privacy reasons. Nevertheless, at least 19% of survey participants indicated having obtained a degree outside Belgium (165/890 respondents, 254 not answering the question), with

156 specifying in which country: 118 had obtained a degree inside the European Economic Area, with France (n = 21), The Netherlands (n = 21), Germany (n = 20), Italy (n = 16), and United Kingdom (n = 15) as the most mentioned countries. Various other regions were also represented: North America (9 in the United States, 5 in Canada), Asia (3 in China, 3 in India, 1 in South Korea), Africa (2 in South Africa, 1 in Morocco, 1 in Kenya, 1 in Zimbabwe), the Middle East (3 in Iran, 1 in Israel), South America (1 in Venezuela, 1 in Cuba, 1 in Brazil), 2 in Russia and 2 in Australia. 1 respondent indicated an unknown or invalid region.

Discussion

Within the limits of our cross-sectional survey of self-reported personal and observed misbehavior, we may conclude that, in spite of reassuring claims,[7-8] research misconduct occurs to a substantial degree within both universities and industry. Overall, the reporting of research misconduct was lower in industry compared to universities, expect for plagiarism.

A novelty and strength of our survey compared to previous studies,[1-2] is that we also included researchers working in industry. Nevertheless, our study also has limitations. First, privacy issues initially complicated obtaining the e-mail addresses of potential participants, especially from industry. Some companies were initially suspicious and reluctant to participate, despite our pledges of full anonymity, and certain big corporations eventually declined after

months of intense communication. Several companies wanted to read the article before its publication. Second, our survey does not allow us to explain why we found a possibly lower prevalence of research misconduct in industry than in universities. We cannot exclude a selection bias (with the ‘‘most ethical’’ fraction of the industrial population having been invited or having consented to participate in the survey) or a reporting bias (with respondents from industry having been more inclined to give socially acceptable replies). However, the prevalence of self-reported admitted and observed research misconduct may well be truly lower in industry than in universities. Nevertheless, it has been suggested that the case that research performed by industry is technically clean, does not necessarily guarantee that its conclusions are unbiased, let alone ethical.[27] Third, one could question the generalizability of a study that was done in a single, small country. However, our participants had various international backgrounds and they worked in a wide range of organizations, including multinational pharmaceutical companies. There are no reasons to assume that the Belgian research situation differs from that of other industrialized Western countries. Finally, one could object that we performed a large number of comparisons and verified many relations. This is why we interpreted single significant p values with caution and adopted a stringent criterion ($p<0.01$) to accept statistical significance.

Fourth, we relied on the (self-) reporting of our respondents, which does not provide a solid base to verify the exact amount of research misconduct that was conducted. In addition, the prevalence of observed research misconduct is challenging to interpret. It is possible

that certain respondents refer to the same case of research misconduct. It is also possible that respondents interpreted the actions of research misconduct we inquired about, in a different way than we had intended. Nevertheless, we used descriptive phrases instead of terms in order to describe the action of research misconduct. Finally, one could criticize the two different modalities to recruit participants: all Belgian universities were included, whereas not all private companies, including several multinational corporations, accepted to participate. We do not know to what extent this selective participation by organization introduced a systematic bias. Neither do we know how this may have introduced bias at the level of individual respondents. Unfortunately we have no way of asserting the level of bias. However, our study is the first study that also included researchers working in industry.

The prevalences of admitted and observed misconduct actions in our survey proved to be generally of similar magnitude as those found in other surveys on research integrity.[1-2,28-29] However, the prevalence of 'credit misconduct' stands out as being much higher in our survey than in the previous USA survey.[1] This is partly explained by differences in the way the category of 'credit misconduct' was built. In the USA survey, plagiarism (one of the components of 'credit misconduct') was admitted to by 1% of the respondents, compared to 3% in our survey.[1] In addition, in the USA survey, 10% admitted to "inappropriately assigning authorship credit", whereas in our survey, where two questions referred to this issue, 2% admitted to "denying authorship credit to someone who has contributed substantively", but

up to 42% to "giving authorship credit to someone who has not contributed substantively".[1]

According to Stroebe et al. most research misconduct cases are brought to light by whistleblowers.[30] Therefore, it is remarkable that respondents from universities appear more reluctant than those active within industry to report research misconduct. Consequently, many instances of research misconduct might remain unnoticed and, therefore, unsanctioned. Such impunity may favor a culture where research misconduct and questionable research practices become tolerated or even considered 'normal' research practice.

Previous research has questioned the effectiveness of research integrity training to reduce research misconduct and strongly underlined the impact of mentorship on the prevalence of research misconduct.[16,31] We also found a relation between mentoring and the reporting rate of research misconduct, as well as a (strong) relation between research integrity training and reporting research misconduct. Receiving informal research integrity training, resulted in a higher reporting rate of research misconduct. In contrast, respondents having received formal research integrity training, namely a section on research integrity within other courses, were less likely to observe and admit to research misconduct. Of note, respondents from universities reported having received less formal research integrity training compared to industry.

A recent meta-analysis has shown evolutions in the least years concerning research integrity training. It concludes that such trainings in general are improving. However, the authors emphasize that there is

still room for improvement. Several elements have an effect on the impact of research integrity training, including the characteristics of the trainers as well as the trainees, the format, the scope, and the frequency by which the trainings are given.[32] It is noteworthy that concerning these vital elements, there is no consensus in the European guidance documents on research integrity.[33]

In spite of the ever increasing collaboration between industry and universities, contextual differences between these various environments have been largely ignored in research integrity guidance documents.[13-14] Guidelines that are not based on empirical data, but on assumptions and mutual distrust, might unnecessarily hinder industry–university collaborations.[7-8]

Various questions raised by our research remain unanswered. How can the observed difference in reporting between industry and universities be explained? Why is there such a difference in the reporting of credit misconduct within our survey compared to previous surveys? Does research integrity training effectively stimulate research integrity in the daily research practice or does it rather correlate with providing more socially desirable answers to our survey? Nonetheless, our research demonstrates that, despite the increased attention given to (un)acceptable research practices, a substantial part of biomedical researchers and research managers still engage in research misconduct.

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Author contribution

BN and KD contributed to the study design, the elaboration of the manuscript, and supervised the research. Statistical analyses were performed by SF. SG contacted the organizations involved, performed the validation of the survey and the pilot study, performed the study and wrote the first and successive drafts of the manuscript. All authors approved the final version.

Conflict of interest

The authors declare that they have no conflict of interest.

Figure 1: Flowchart providing an overview of respondents to our survey.

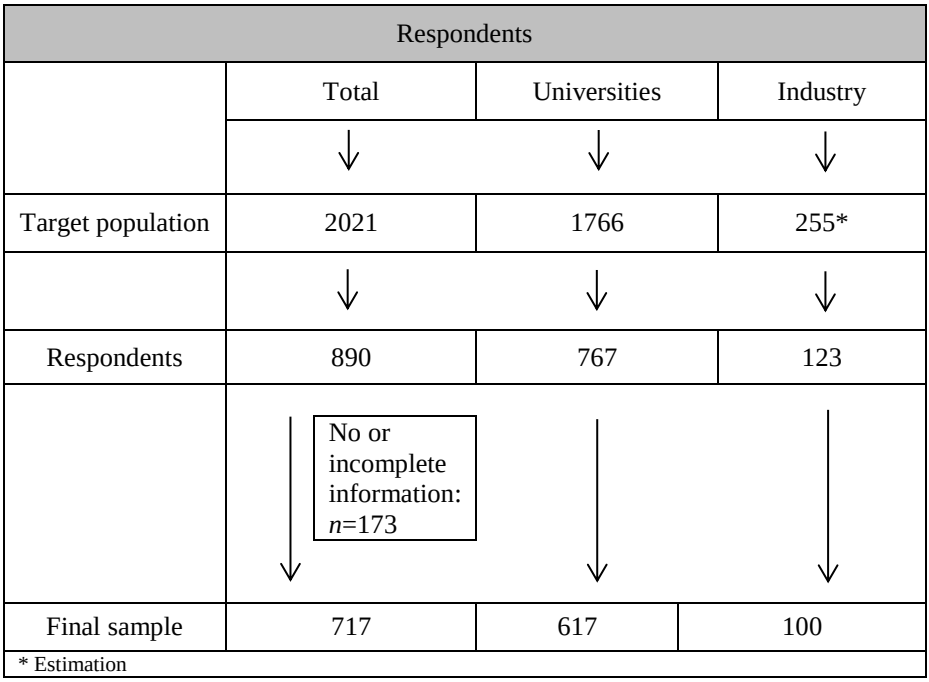

Table 1: List of 22 actions of research misconduct, grouped per category.

Actions of research misconduct	Categories of research misconduct
1. Dropping observations or data points from analyses based on a gut feeling they were inaccurate 2. Willfully distorting research results or data 3. Knowingly overlooking others' use of flawed data or methods 4. Inventing research data or cases. 5. Failing to present data that contradict one's own previous research.	1) Data misconduct
6. Inadequate record keeping or data management related to research projects 7. Using inadequate or inappropriate research designs 8. Withholding key aspects of methodology in papers or proposals	2) Methods misconduct
9. Circumventing or ignoring aspects of materials-handling requirements (e.g. biosafety, radioactive) 10. Circumventing or ignoring aspects of human-subjects research requirements (e.g. informed consent, …) 11. Circumventing or ignoring aspects of animal-subjects research requirements	3) Policy misconduct

12. Unauthorized use of confidential information in connection with one's own research 13. Not properly disclosing involvement in firms whose products are based on one's own research 14. Changing the results or conclusions of a study in response to pressure from funding source	4) Outside influence misconduct
15. Using another's words, data or ideas without giving due credit 16. Denying authorship credit to someone who has contributed substantively to a manuscript 17. Publishing, as original research, ones previously published data or results 18. Giving authorship credit to someone who has not contributed substantively to a manuscript	5) Credit misconduct
19. Inadequate monitoring of research projects due to work overload 20. Cutting corners in a hurry to complete a project 21. Continued unintentional carelessness in conducting research 22. Inappropriate or careless review of papers or proposals	6) Cutting corners misconduct

Table 2: List of predictors for reported (admitted and observed) research misconduct.

	N(%) subjects with available information	Universities	Industry	P-value
Gender	636 (89%)			0.425
Female		46%	41%	
Male		54%	59%	
Age	634 (88%)			<0.001
Mean (SD)		38 (11)	44 (10)	
20-29		26%	4%	
30-39		36%	31%	
40-49		20%	39%	
>= 50		18%	26%	
Management level	717 (100%)			<0.001
Higher Management		26%	20%	
Middle Management		29%	35%	
Lower Management		15%	31%	
Not Applicable		30%	14%	
Obtained a degree outside Belgium	636 (89%)	23%	43%	<0.001
Obtained a PhD	636 (89%)	73%	70%	0.524
Mentorship[§]:	717 (100%)			
Help in developing professional relationships with others in your field		82%	71%	0.015
Assistance in writing for presentation and publication		93%	87%	0.036
Instruction in the details of good research practice		77%	78%	1.000
Continuing interest in your progress		92%	91%	0.687

Emotional support when needed		67%	56%	0.042
Help in learning the art of survival in your field		65%	56%	0.092
Assistance in obtaining financial support		84%	61%	<0.001
Research integrity training[§§]	641 (89%)			
More formal research integrity training				
A face-to-face classroom course focused specifically on research integrity		29%	34%	0.386
A section on research integrity within other courses in your field		35%	48%	0.025
Online course focused specifically on research integrity		14%	42%	<0.001
More informal research integrity training				
Workshops, conferences, roundtable discussions, etc.		45%	37%	0.138
Discussions with instructors, mentors, or colleagues		82%	81%	0.883

A comparison is made between respondents from universities and industry. P-values are from Fisher's exact tests or Mann-Whitney-U tests.
[§] Some/a lot versus none
[§§] A great deal/some versus none

Table 3: Industry- university comparison of reporting rate of observed research misconduct.

					Univariable		Multi A		Multi B	
		Total (*n*=717)	Industry (*n*=100)	Academia (*n*=617)	OR (95%CI)	P	OR (95%CI)	P	OR (95%CI)	P
Data misconduct	Dropping data based on a gut feeling	40%	36%	41%	0.81 (0.52;1.25)	0.345	0.90 (0.56;1.45)	0.661		.
	Falsification (wilfully distorting research results or data)	12%	9%	12%	0.70 (0.34;1.46)	0.344	0.68 (0.31;1.47)	0.329	0.54 (0.25;1.16)	0.117
	Overlooking others' use of flawed data or methods	17%	10%	19%	0.49 (0.24;0.96)	0.038	0.53 (0.26;1.09)	0.083	0.51 (0.25;1.02)	0.058
	Fabrication (inventing research data or cases)	4%	3%	4%	0.73 (0.22;2.47)	0.616	0.67 (0.18;2.42)	0.539		.
	Not presenting data that contradicting previous research	21%	20%	21%	0.92 (0.54;1.55)	0.752	0.99 (0.57;1.75)	0.985		.
Methods misconduct	Inadequate record keeping or data management	48%	41%	49%	0.72 (0.47;1.11)	0.141	0.78 (0.49;1.24)	0.292		.
	Using inadequate or inappropriate research designs	45%	39%	46%	0.74 (0.48;1.14)	0.172	0.78 (0.49;1.23)	0.283	0.72 (0.46;1.12)	0.1460
	Withholding key aspects of methodology	17%	12%	18%	0.61 (0.33;1.16)	0.135	0.67 (0.34;1.32)	0.247		.
Policy misconduct	Circumventing materials-handling requirements	32%	21%	34%	0.52 (0.31;0.87)	0.013	0.57 (0.33;0.98)	0.043	0.57 (0.33;0.97)	0.039

	Circumventing human-subjects research requirements	17%	9%	18%	0.44 (0.21;0.89)	0.023	0.44 (0.20;0.93)	0.032	0.40 (0.19;0.85)	0.016
	Circumventing animal-subjects research requirements.	13%	5%	15%	0.31 (0.12;0.78)	0.013	0.29 (0.11;0.76)	0.012	0.29 (0.11;0.74)	0.009
Outside influence misconduct	Unauthorized use of confidential information	9%	5%	9%	0.51 (0.20;1.30)	0.157	0.49 (0.18;1.30)	0.152	0.43 (0.16;1.14)	0.090
	Not properly disclosing involvement in firms	5%	3%	5%	0.55 (0.16;1.82)	0.325	0.69 (0.19;2.44)	0.560		.
	Changing the results in response to pressure from funder	4%	4%	4%	1.13 (0.38;3.34)	0.829	1.10 (0.34;3.49)	0.875		.
Credit misconduct	Plagiarism (coping words/data/ideas without credit)	36%	51%	34%	2.02 (1.32;3.09)	0.001	1.97 (1.24;3.11)	0.004	2.10 (1.36;3.24)	<0.001
	Denying authorship credit	33%	29%	34%	0.80 (0.50;1.27)	0.338	0.83 (0.51;1.36)	0.465		.
	Publishing again one's previously published data	9%	6%	10%	0.60 (0.25;1.44)	0.254	0.60 (0.24;1.51)	0.279		.
	Gift authorship	72%	50%	76%	0.32 (0.21;0.50)	<.0001	0.42 (0.26;0.68)	<0.001	0.41 (0.26;0.67)	<0.001
Cutting corners misconduct	Inadequate monitoring of research projects	65%	54%	67%	0.59 (0.38;0.90)	0.015	0.74 (0.46;1.18)	0.210	0.65 (0.42;1.01)	0.056
	Cutting corners in a hurry to complete a project	33%	34%	33%	1.04 (0.67;1.63)	0.853	1.03 (0.64;1.66)	0.909		.
	Continued carelessness in conducting research	25%	16%	27%	0.53 (0.30;0.92)	0.025	0.55 (0.31;1.00)	0.048	0.53 (0.30;0.95)	0.032
	Inappropriate or careless review of papers or proposals	27%	18%	28%	0.56 (0.33;0.97)	0.037	0.56 (0.32;1.00)	0.050	0.55 (0.32;0.96)	0.035

Total	Observed at least one of the 22 listed actions	91%	84%	93%	0.42 (0.23;0.78)	0.006	0.58 (0.28;1.19)	0.138	0.35 (0.18;0.68)	0.002

The actions listed are abbreviated forms of the full questions asked, which can be found in Table 1.
Odds ratios (industry versus university) for the difference in reported behavior between industry and academia. Model A= result from the multivariable model with correction for factors age, gender, obtained a PhD, obtained a degree abroad, and level of management. Model B=result from multivariable model considering all variables and applying a backward stepwise model selection. In the multivariable model B no odds ratio is reported for the effect of context if context was not retained as factor in the multivariable model. No univariable odds ratios were given if in academia and/or industry the behavior is not observed/reported. No multivariable models were fitted if the total number of events was lower than 10.

Table 4: Industry-university comparison of reporting rate of admitted research misconduct.

					Univariable		Model A		Model B	
		Total (*n*=717)	Industry (*n*=100)	Academia (*n*=617)	OR (95%CI)	P	OR (95%CI)	P	OR (95%CI)	P
Data misconduct	Dropping data based on a gut feeling	15%	15%	15%	1.02 (0.56;1.84)	0.947	1.26 (0.66;2.42)	0.484		.
	Falsification (wilfully distorting research results or data)	0%	0%	0%		.		.		.
	Overlooking others' use of flawed data or methods	6%	4%	6%	0.67 (0.23;1.93)	0.461	0.68 (0.22;2.11)	0.506		.
	Fabrication (inventing research data or cases)	0%	1%	0%		.		.		.
	Not presenting data contradicting previous research.	4%	2%	4%	0.45 (0.10;1.91)	0.276	0.49 (0.11;2.23)	0.357	0.32 (0.07;1.40)	0.131
Methods misconduct	Inadequate record keeping or data management	27%	22%	27%	0.75 (0.45;1.24)	0.259	0.80 (0.47;1.36)	0.406		.
	Using inadequate/inappropriate research designs	15%	17%	15%	1.17 (0.66;2.06)	0.590	1.17 (0.63;2.19)	0.615		.
	Withholding key aspects of methodology	5%	3%	5%	0.57 (0.17;1.88)	0.353	0.61 (0.18;2.15)	0.446		.
Policy misconduct	Circumventing materials-handling requirements	11%	4%	13%	0.29 (0.10;0.80)	0.018	0.31 (0.11;0.91)	0.033	0.28 (0.10;0.79)	0.016

	Circumventing human-subjects research requirements	5%	2%	5%	0.39 (0.09;1.64)	0.197	0.34 (0.07;1.60)	0.171		.
	Circumventing animal-subjects research requirements.	3%	1%	3%	0.32 (0.04;2.40)	0.267	0.30 (0.03;2.53)	0.267		.
Outside influence misconduct	Unauthorized use of confidential information	1%	2%	1%	1.78 (0.36;8.69)	0.477		.		.
	Not properly disclosing involvement in firms	1%	1%	1%	1.55 (0.17;13.99)	0.697		.		.
	Changing results in response to pressure from funder	0%	1%	0%	3.11 (0.28;34.58)	0.357		.		.
Credit misconduct	Plagiarism (coping words/data,/ideas without credit)	4%	7%	3%	2.37 (0.97;5.79)	0.058	2.62 (1.00;6.83)	0.049	2.86 (1.13;7.26)	0.027
	Denying authorship credit	2%	1%	2%	0.51 (0.07;3.96)	0.519	0.52 (0.06;4.25)	0.538		.
	Publishing again one's previously published data	0%	1%	0%	3.11 (0.28;34.58)	0.357		.		.
	Gift authorship	40%	25%	42%	0.46 (0.28;0.74)	0.001	0.50 (0.30;0.84)	0.008	0.52 (0.32;0.85)	0.009
Cutting corners misconduct	Inadequate monitoring of research projects	36%	37%	36%	1.04 (0.67;1.61)	0.868	1.13 (0.70;1.83)	0.617		.
	Cutting corners in a hurry to complete a project	13%	18%	12%	1.64 (0.93;2.88)	0.088	1.44 (0.77;2.67)	0.252	1.98 (1.10;3.55)	0.022
	Continued carelessness in conducting research	2%	2%	2%	1.12 (0.25;5.15)	0.880	1.26 (0.24;6.51)	0.783		.
	Inappropriate review of papers or proposals	4%	4%	4%	1.08 (0.36;3.18)	0.895	0.61 (0.18;2.08)	0.431		.
Total	Admitted at least one of the 22 listed actions	70%	61%	71%	0.63 (0.48;0.97)	0.035	0.69 (0.42;1.12)	0.138	0.70 (0.44;1.10)	0.124

The actions listed are abbreviated forms of the full questions asked , which can be found in Table 1.
Odds ratios (industry versus university) for the difference in reported behavior between industry and academia. Model A= result from the multivariable model with correction for factors age, gender, obtained a PhD, obtained a degree abroad, and level of management. Model B=result from multivariable model considering all variables and applying a backward stepwise model selection. In the multivariable model B no odds ratio is reported for the effect of context if context was not retained as factor in the multivariable model. No univariable odds ratios were given if in academia and/or industry the behavior is not observed/reported. No multivariable models were fitted if the total number of events was lower than 10.

Table 5: Industry-university comparison of reporting rate of research misconduct per category.

					Univariable		Multi A		Multi B	
		Total (*n*=717)	Industry (*n*=100)	Academia (*n*=617)	OR (95%CI)	P	OR (95%CI)	P	OR (95%CI)	P
Reportedly observed behavior	Data misconduct	55%	47%	56%	0.69 (0.45;1.05)	0.086	0.765 (0.48;1.22)	0.264	0.661 (0.43;1.02)	0.060
	Methods misconduct	66%	60%	67%	0.75 (0.49;1.16)	0.197	0.795 (0.49;1.30)	0.358		.
	Policy misconduct	45%	29%	48%	0.45 (0.28;0.71)	<0.001	0.428 (0.26;0.71)	0.001	0.393 (0.24;0.64)	<0.001
	Outside influence misconduct	16%	11%	16%	0.63 (0.33;1.22)	0.173	0.621 (0.30;1.27)	0.191	0.600 (0.30;1.19)	0.146
	Credit misconduct	81%	70%	83%	0.49 (0.30;0.79)	0.003	0.695 (0.40;1.20)	0.195	0.535 (0.33;0.87)	0.012
	Cutting corners misconduct	75%	66%	76%	0.60 (0.38;0.94)	0.025	0.697 (0.42;1.16)	0.165	0.641 (0.40;1.02)	0.062
Reportedly admitted behavior	Data misconduct	21%	21%	21%	0.99 (0.59;1.66)	0.958	1.449 (0.95;2.21)	0.085		.
	Methods misconduct	36%	34%	36%	0.90 (0.58;1.41)	0.656	0.916 (0.56;1.49)	0.722		.
	Policy misconduct	17%	6%	19%	0.28 (0.12;0.64)	0.003	0.267 (0.11;0.66)	0.004	0.278 (0.12;0.66)	0.004
	Outside inflence misconduct	2%	4%	2%	1.94 (0.62;6.06)	0.257	1.364 (0.39;4.83)	0.631		.

	Credit misconduct	41%	31%	43%	0.59 (0.38;0.93)	0.024	0.615 (0.38;1.01)	0.053	0.669 (0.42;1.07)	0.092
	Cutting corners misconduct	43%	43%	43%	1.02 (0.66;1.56)	0.944	1.070 (0.67;1.72)	0.781		.

Odds ratios (industry versus university) for the difference in reported behavior between industry and academia. Model A= result from the multivariable model with correction for factors age, gender, obtained a PhD, obtained a degree abroad, and level of management. Model B=result from multivariable model considering all variables and applying a backward stepwise model selection. In the multivariable model B no odds ratio is reported for the effect of context if context was not retained as factor in the multivariable model. No univariable odds ratios were given if in academia and/or industry the behavior is not observed/reported. No multivariable models were fitted if the total number of events was lower than 10.

Supplementary appendix

Table 6: Overview of the relations between predictors and reporting rate of observed research misconduct per category.

	Data		Methods		Policy		Outside influence		Credit		Cutting corners	
	OR (95%CI)	p	OR (95%CI)	p	OR (95%CI)	p	OR (95%CI)	p	OR (95%CI)	p	OR (95%CI)	p
Group (industry versus academia)	0.661 (0.430;1.018)	0.0604			0.393 (0.240;0.642)	0.0002	0.600 (0.302;1.194)	0.146	0.535 (0.329;0.873)	0.012	0.641 (0.402;1.023)	0.062
Management level								0.017				
Higher Management							3.073 (1.470;6.422)	0.003				
Lower Management							1.685 (0.738;3.847)	0.216				
Middle Management							2.718 (1.327;5.568)	0.006				
Not Applicable							#	.				
Gender							1.439 (0.843;2.457)	0.185				
Age (categorised into 20-29, 30-39, 40-49 and >=50												
Phd degree (yes/no)			1.582 (1.099;2.278)	0.014	0.623 (0.429;0.904)	0.013	1.783 (0.864;3.679)	0.118	1.697 (1.083;2.658)	0.022	1.453 (0.956;2.208)	0.081
Degree obtained outside Belgium (yes/no)									0.659 (0.417;1.043)	0.076	0.601 (0.404;0.894)	0.012
Mentorship (7 yes/no items)[§]:												
- Help in developing professional relationships with others in your field												
- Assistance in writing for presentation and publication												
- Instruction in the details of good research practice	0.544 (0.372;0.794)	0.002	0.639 (0.424;0.963)	0.032							0.711 (0.453;1.114)	0.136
- Continuing interest in your progress												
- Emotional support when needed			0.655 (0.461;0.930)	0.018	0.767 (0.535;1.101)	0.151	0.543 (0.354;0.834)	0.005			0.760 (0.520;1.111)	0.157
- Help in learning the art of survival in your field					0.758 (0.530;1.085)	0.131						
- Assistance in obtaining financial support					0.682 (0.453;1.025)	0.066						
Training												
- A face-to-face classroom course focused specifically on research integrity												
- A section on research integrity within other courses in your field					0.588 (0.408;0.847)	0.005						
- Workshops, conferences, roundtable discussions, etc.	0.628 (0.455;0.868)	0.005					1.785 (1.130;2.820)	0.013				
- Discussions with instructors, mentors, or colleagues	1.703 (1.111;2.610)	0.015	1.647 (1.050;2.581)	0.030	1.665 (1.066;2.600)	0.026						
- Online course focused specifically on research integrity			0.650 (0.425;0.993)	0.046								

Results from the multivariable models on topic level obtained after backward stepwise selection (model B). Note that results are only given when the variable is retained in the model.

Table 7: Overview of the relations between predictors and reporting rate of admitting to research misconduct per category.

	Data		Methods		Policy		Outside influence		Credit		Cutting corners	
	OR (95%CI)	p	OR (95%CI)	p	OR (95%CI)	p	OR (95%CI)	p	OR (95%CI)	p	OR (95%CI)	p
Group (industry versus academia)					0.278 (0.118;0.656)	0.004	2.615 (0.745;9.171)	0.133	0.669 (0.419;1.068)	0.092		
Management level												
- Higher Management												
- Lower Management												
- Middle Management												
- Not Applicable												
Gender	1.392 (0.911;2.127)	0.128										
Age (categorised into 20-29, 30-39, 40-49 and >=50		0.011										
20-29	2.269 (1.177;4.377)	0.015										
30-39	1.359 (0.762;2.422)	0.298										
40-49	0.899 (0.470;1.719)	0.747										
>=50	#	.										
Phd degree (yes/no)					0.561 (0.358;0.878)	0.012			1.906 (1.313;2.766)	<0.001	1.634 (1.133;2.355)	0.009
Degree obtained outside Belgium (yes/no)									0.673 (0.460;0.985)	0.042	0.554 (0.378;0.811)	0.003
Mentorship (7 yes/no items)[§]:												
- Help in developing professional relationships with others in your field					0.736 (0.490;1.105)	0.139						
- Assistance in writing for presentation and publication	1.958 (0.874;4.383)	0.102										
- Instruction in the details of good research practice									0.706 (0.491;1.017)	0.061	0.725 (0.504;1.044)	0.084
- Continuing interest in your progress												
- Emotional support when needed			0.759 (0.552;1.044)	0.090								
- Help in learning the art of survival in your field												
- Assistance in obtaining financial support	0.536 (0.337;0.854)	0.009					0.436 (0.148;1.283)	0.132				
Training												
- A face-to-face classroom course focused specifically on research integrity												
- A section on research integrity within other courses in your field					0.547 (0.334;0.898)	0.018			0.774 (0.546;1.095)	0.149	0.558 (0.393;0.792)	0.001
- Workshops, conferences, roundtable discussions, etc.							5.010 (1.548;16.219)	0.007				
- Discussions with instructors, mentors, or colleagues												
- Online course focused specifically on research integrity	0.580 (0.324;1.039)	0.067	0.668 (0.427;1.045)	0.078			0.126 (0.015;1.026)	0.053				
Results from the multivariable models on topic level obtained after backward stepwise selection (model B). Note that results are only given when the variable is retained in the model												

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Chapter three: How do biomedical researchers morally evaluate their own research misconduct and that of others?

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Introduction

Research misconduct occurs to a substantial degree in biomedical research.[1-6] We recently determined, by means of a large computer-based survey, how often biomedical researchers and research managers active in industry and universities admitted to have committed various types of research misconduct and how often they had observed such actions among their colleagues.[6]

Various factors, including publication pressure and received mentoring, have been shown or hypothesized to play a role in committing research misconduct.[7-9] Few studies however have been published on how biomedical researchers and research managers ethically evaluate research misconduct.[10-11] Nevertheless data concerning this ethical evaluation is important from the perspective of empirical ethics because it demonstrates what aspects of research misconduct are relevant for the biomedical researchers and research managers themselves. In

addition, their attitudes and experiences concerning research misconduct are a source of ethics in itself.[12] Therefore, in this paper, we focused on the normativity concerning research misconduct as perceived by biomedical researchers and research managers: how do they evaluate actions generally considered to be research misconduct and what actions do they consider to be (un)acceptable? Based on such empirical data, we can make their evaluations and experiences more explicit by investigating possible relations with certain predictors. This analysis is important to develop an agreed upon and effective research integrity policy.

We hypothesized that their ethical evaluation relates with various predictors: work context (industry versus universities), whether or not they reported research misconduct, aspects of general moral character, age, gender as well as received mentoring and research integrity training.

Methods

This article is based on the methods and analysis of original findings obtained from a study of which we already presented the prevalence of self-reported and observed research misconduct.[6] As we described previously, we used an adapted USA survey based on previous research findings.[1,6,13-14] Approval for this study was obtained from both the national Privacy Commission and the "Social and Societal Ethics Committee" of the University of Leuven. We guaranteed individual participants and their organizations absolute anonymity.

In this paper we present the similarities and differences of the ethical evaluation towards research misconduct between respondents active in industry compared to those active in universities. To obtain this information, respondents were asked to score the moral acceptability of each item on a 5-point Likert scale, ranging from 1 (integrity) to 5 (misconduct). In our analysis, we grouped the provided scores in three categories: 1 to 2 as integrity, 3 as neutral, and 4 to 5 as misconduct. These data allow us to investigate the relation between the ethical evaluation of research misconduct and the reporting of research misconduct.

We also evaluate respondents' ethical evaluation of lying, cheating and stealing by asking them to score, in a similar way, the following items: "claim non existing credentials or work experience in the curriculum vitae or the resume" (lying); "unlawfully avoiding paying taxes" (cheating); "taking something of minor financial value from work for personal use without paying for it" (minor stealing); and "taking something of major financial value from work for personal use without paying for it" (major stealing). These data allow us to investigate the relation between the ethical evaluation of research misconduct and aspects of general moral character. Admittedly a rough, somewhat superficial assessment. Finally, we analyze the relations between the ethical evaluations of research misconduct and various possible predictors (see Table 1).

Statistical analyses

Fisher's exact tests and Mann-Whitney-U tests were used to compare variables between respondents active in universities and industry. Ethical evaluation scores were compared between various items with a Wilcoxon signed rank test. Multivariable linear regression models were used to evaluate possible predictors of the ethical evaluation. Analyses have been performed for each of the 22 items. A multivariate imputation was used to handle missing information (see Table 1 for information on the percentage missing values per predictor) in the predictors. Two versions of the multivariable model were considered. First, the difference between university and industry was evaluated after correction for age, gender, having obtained a PhD, having obtained a degree abroad, and level of management (multivariable model A). Second, having received mentoring and research integrity training, and ethical evaluation towards forms of lying, stealing and cheating were added and a backward stepwise model building was performed (multivariable model B). More information can be found in our previous article.[6] From the multivariable models, estimates (with 95% confidence intervals) were derived which refer to the effect on the Likert scale. The multivariable results reported in the text refer to model B. As discussed in our previous article, only p values smaller than 0.01 were considered significant.[6] All analyses have been performed using SAS software, version 9.4 of the SAS System for Windows.

Results

A total of 1766 people active within universities received our survey (Figure 1). The exact denominator was unknown for participants from industry, but we estimated that within industry, 255 people received our survey. In total 890 persons, 767 active in universities and 123 active in industry, responded to the survey, giving response rates of 43% (767/1766) and 48% (123/255), respectively. For some respondents no information (*n*=230) or no complete information (*n*=4) was available for the scores given to the 22 items, leaving an analysis sample of 656 subjects in total (565 in universities and 91 in industry).

Although the Belgian National Academy of Science published a national research integrity guideline in 2009,[15] the majority of respondents (92% in industry and 81% in universities) responded negatively or "don't know" to the question of whether Belgium has a national guideline on research ethics. Nonetheless, the majority of the respondents (79% in industry and 68% in universities) did believe that a guideline would strongly contribute to the prevention of research misconduct.

Ethical evaluation of research misconduct: industry versus universities

International research integrity guidance generally considers fabrication and falsification of data, and plagiarism to be the most serious forms of research misconduct. These items were mentioned most frequently in all the definitions of the national guidance documents in

the European Economic Area.[13] They also constitute the essential definition of research misconduct in many other countries, for example the USA.[16] However, based on the scores given on the Likert scale, the three items considered the most serious forms of research misconduct by respondents of industry and universities were falsification of data, "unauthorized use of confidential information in connection with one's own research", and "changing the results or conclusions of a study in response to pressure from a funding source".

Only two items of research misconduct were convincingly considered closer to misconduct within universities compared to industry (see Table 2): "denying authorship credit to someone who has contributed substantively to a manuscript" ($p=0.003$), and plagiarism ($p<0.001$). When we considered the overall distribution of the means of the scores, we observed some non-significant differences between industry and universities (Figure 2 and 3). Within industry more respondents (8%) compared to universities (3%), tended to provide a score of 1 or 2, i.e. closer to acceptable behavior. ($p=0.074$).

The respondents considered "unauthorized use of confidential information in connection with one's own research", and "changing the results or conclusions of a study in response to pressure from funding source" significantly more unacceptable than fabrication of data and plagiarism ($p<0.0001$). A non-negligible part of the respondents considered both fabrication of data (18% within universities and 23% within industry) and plagiarism (16% within universities and 30% within industry) to be ethically neutral or even acceptable items (scores of 1 to 3 on the 5 point Likert scale).

The respondents considered the following five items to be the least objectionable: “withholding key aspects of methodology in papers or proposals”, “inappropriate or careless review of papers or proposals”, “inadequate record keeping or data management related to research projects”, “giving authorship credit to someone who has not contributed substantively to a manuscript”, “inadequate monitoring of research projects due to work overload”.

Ethical evaluation of research misconduct versus reporting of research misconduct

We found a generally strong and consistent negative relation between the ethical evaluation and admitting of research misconduct (See Table 3). This relation was significant at p=0.01 for 13 of the 22 items. No significant relations were apparent however between the ethical evaluation of research misconduct and the reporting rate of observed these items being conducted by colleagues.

Ethical evaluation of research misconduct versus aspects of ‘general’ moral character

Relations existed between the ethical evaluation of lying, stealing and cheating and the ethical evaluation towards the listed 22 items (Table 4). In general, when lying and cheating were considered less acceptable, the 22 items of research misconduct were also considered less acceptable. This relationship was consistently significant with lying for 19 of the 22 items at p=0.01. For cheating it was significant for four items: fabrication of data (p=0.005); “circumventing or ignoring

aspects of human-subjects research requirements" ($p=0.003$); "circumventing or ignoring aspects of animal-subjects research requirements" ($p<0.0001$); and "giving authorship credit to someone who has not contributed substantively to a manuscript" ($p=0.002$).

A significant relation existed between the ethical evaluation of stealing and the ethical evaluation of the 22 items on research misconduct ($p<0.0001$). We could distinguish three groups: those respondents that evaluated minor stealing to be more acceptable, but major stealing to be less acceptable (group one: 37% of our respondents); those respondents that evaluated minor and major stealing to be both more acceptable (group two: 7% of our respondents); finally those respondents that evaluated both minor and major stealing to be unacceptable (group three: 56% of our respondents). Respondents within group three were significantly more lenient in their ethical evaluation of 20 items of research misconduct ($p<0.0001$) compared to respondents within group one. Additionally, respondents within group two considered 9 out of the 22 items to be significantly less acceptable, compared to respondents within group one. However, for "unauthorized use of confidential information in connection with one's own research" ($p=0.007$), the relation was the opposite.

Relations with various predictors and ethical evaluation of research misconduct

The scores given to the 22 items of research misconduct were also related to other predictors (Tables 5-7). Men were more lenient than women in their ethical evaluation towards "inadequate monitoring of

research projects due to work overload" (p=0.001) (Table 5). No significant relations with age were observed. Respondents having completed a degree outside Belgium were more lenient in their ethical evaluation towards 13 items, significantly for three of them: "unauthorized use of confidential information in connection with one's own research" (p=0.008); "changing the results or conclusions of a study in response to pressure from funding source" (p=0.004); and "publishing, as original research, one's previously published data or results" (p=0.007) (Table 5).

Respondents who had received informal research integrity training ("workshops, conferences, and roundtable discussions") evaluated "inappropriate or careless review of papers or proposals" (p=0.009) to be less acceptable (Table 6). Respondents having received formal research integrity trainings were generally more lenient in their ethical evaluation of the items of research misconduct, but not significantly (Table 6). Receiving mentoring as "help developing professional relationships with others in your field" related with evaluating several items to be less acceptable and opposite effects were observed mainly for "help in learning the art of survival in your field" (Table 7). However, none of these relations were significant.

Discussion

In line with our hypotheses, several predictors related with the ethical evaluation of research misconduct. Respondents of universities and industry give a similar ranking of the ethical evaluation of the 22

items, but, overall, industry proved to be more lenient. This findings are in line with our qualitative research.[14] Various significant relations existed between the ethical evaluation towards research misconduct and admitting to research misconduct. If biomedical researchers and research managers are indeed less inclined to commit research misconduct when they themselves consider these items to be misconduct, this has an impacts on the desirable research integrity policy. A research integrity policy that does not consider the perspectives of the biomedical researchers and research managers, let alone a policy that is not known by those researchers and managers, risks having little impact. Also, when elaborating research integrity training for example, the ethical evaluation of research misconduct should be considered.

Our analysis showed the unfamiliarity of biomedical researchers and research managers with the national Belgian guideline as well as the discrepancy between their perspectives and those of the international research guidance concerning the evaluation of research misconduct. Several of the 22 items that are generally labelled as forms of research misconduct, were often considered more neutral by our respondents. In addition, forms of serious research misconduct were also evaluated differently. As discussed earlier, fabrication and falsification of data, and plagiarism (FFP) are generally considered to be the most serious forms of research misconduct. We included FFP in our list of 22 items, following the description of international research.[2] However, only falsification of data was retained as one of the most serious forms of research misconduct according by our respondents. These

findings are in line with previous studies, which show a greater concern for more common questionable research practices, instead of FFP.[1,10-11] Certainly fabrication and falsification of data are considered rare.

Our study also showed a relation between the evaluation of research misconduct and the ethical evaluation of lying, cheating and stealing. As earlier stated, these analysis was a rather superficial assessment. Nevertheless, this finding is in line with previous research which demonstrated that personality traits, such as Machiavellianism ("a person's tendency to be unemotional, detached from conventional morality and hence inclined to deceive and manipulate others, to focus on unmitigated achievement, and to give high priority to their own performance"),[17] are related with admitting to research misconduct.[18] We hypothesize, based on these findings, that focusing solely on research integrity training in order to alter the ethical evaluation of research misconduct, will prove insufficient.

Informal research integrity training was related with a more rigorous ethical evaluation towards research misconduct. Nevertheless, in our previous paper, such training related with reporting more forms of research misconduct.[6] The combination of these findings suggests that informal training makes researchers and managers more sensitive towards the issues of research misconduct and integrity and, therefore, they are more inclined to report research misconduct.

Formal research integrity training had no significant relation with the ethical evaluation of research misconduct. If anything, the existing relations even indicated that such training related with a less rigorous

evaluation towards research misconduct. A similar relation was generally observed for received mentoring. Interestingly, our previous paper showed that formal training, as well as certain forms of received mentoring, are generally related with a lower reporting of research misconduct, either observed among colleagues or admitted to by themselves.[6] An explanation might be that formal research integrity training, as well as certain forms of mentoring, are strongly focused on instructing researchers and managers that several items are prohibited and, consequently, these items are less committed. Another explanation might be that formal training enabled researchers to make a balanced evaluation between more and less acceptable research practices. Consequently, researchers do not consider all 22 items to be equally (un)acceptable. Thereby certain items become rather "questionable research practices" or are even given a neutral evaluation.

Peer review, good monitoring of research projects, a rigorous data management, and providing enough methodological information in order to reproduce research are often considered to be vital elements in order for the scientific system to prevent research misconduct.[12] Previous research has however questioned the ability of the scientific system to prevent research misconduct through these methods.[12,19-20] In addition, our study shows that respondents evaluated "inadequate monitoring of research projects due to work overload", "inadequate record keeping or data management related to research projects", "inappropriate or careless review of papers or proposals", and even "withholding key aspects of methodology in papers or proposals" as the least objectionable of the listed 22 items. Frequently, a neutral

score was given. If such poor practices are perceived as harmless, this undermines the ability of the scientific system to prevent research misconduct.

However, previous research showed that researchers consider selective reporting and citing, inadequate quality assurance and mentoring as very problematic.[10] The scale used in this research, as well as the respondents to which the survey was aimed, differed from our study. These differences should be taken into account. Nevertheless, further exploration seems necessary.

As indicated in our previous paper concerning the reported behavior of research misconduct, our study has several limitations. Of note, fewer respondents (n=656) filled out the questions concerning ethical evaluation of the 22 items, compared with the questions concerning the reporting rate of the items (n=717). This might be caused by the fact that the ethical evaluation questions came after the reporting questions in our survey.

The observed diversity and the difficulty of interpreting several of our findings underline the complexity of the ethical evaluation of research misconduct by biomedical researchers and research managers themselves. However, we hypothesize that committing research misconduct is also influenced by the ethical evaluation of research misconduct, rather than solely the result of various means of pressure, including pressure to publish and competition.

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Contributions

KD and BN contributed to the study design, the elaboration of the manuscript, and supervised the research. Statistical analyses were performed by SF. SG contacted the organizations involved, performed the validation of the survey and the pilot study, performed the study and wrote the first and successive drafts of the manuscript. All authors approved the final version.

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Conflicts of interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Figure 1: Flowchart with overview of respondents to our survey.

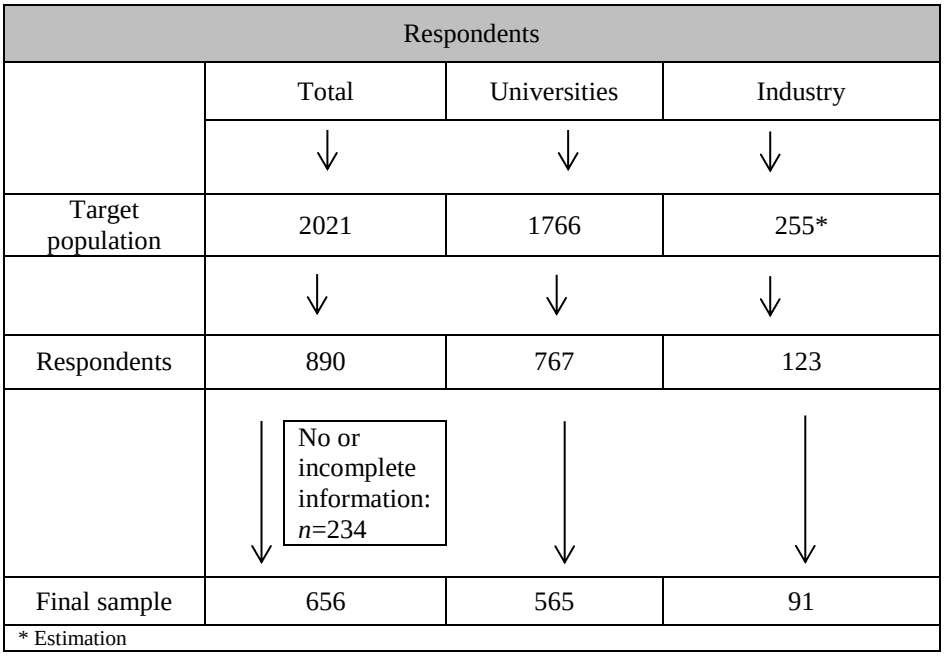

Figure 2: Mean evaluation of research misconduct for respondents from industry.

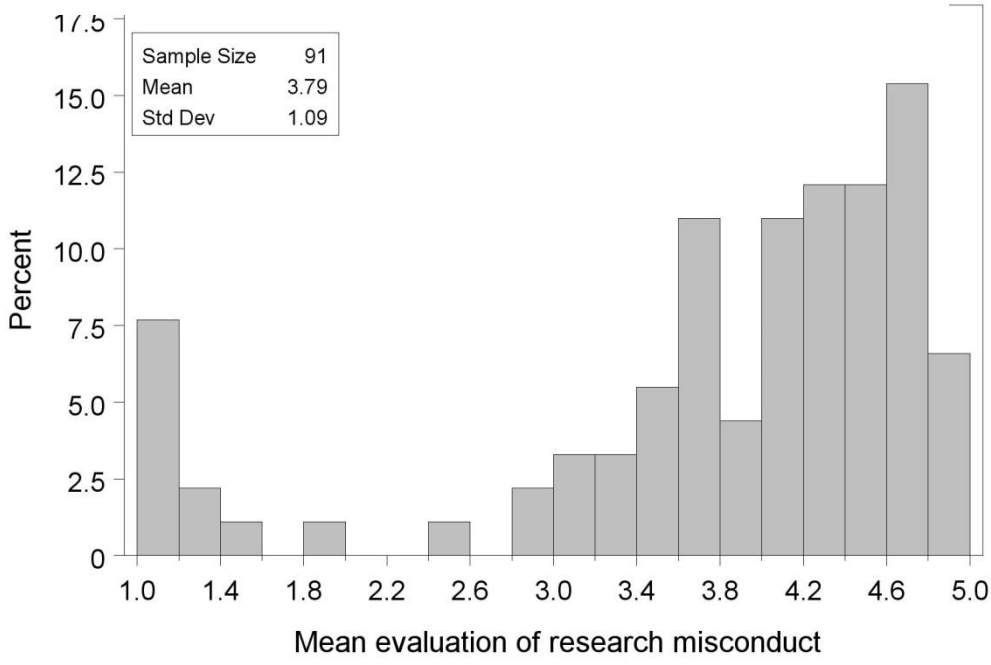

Figure 3: Mean evaluation of research misconduct for respondents from universities.

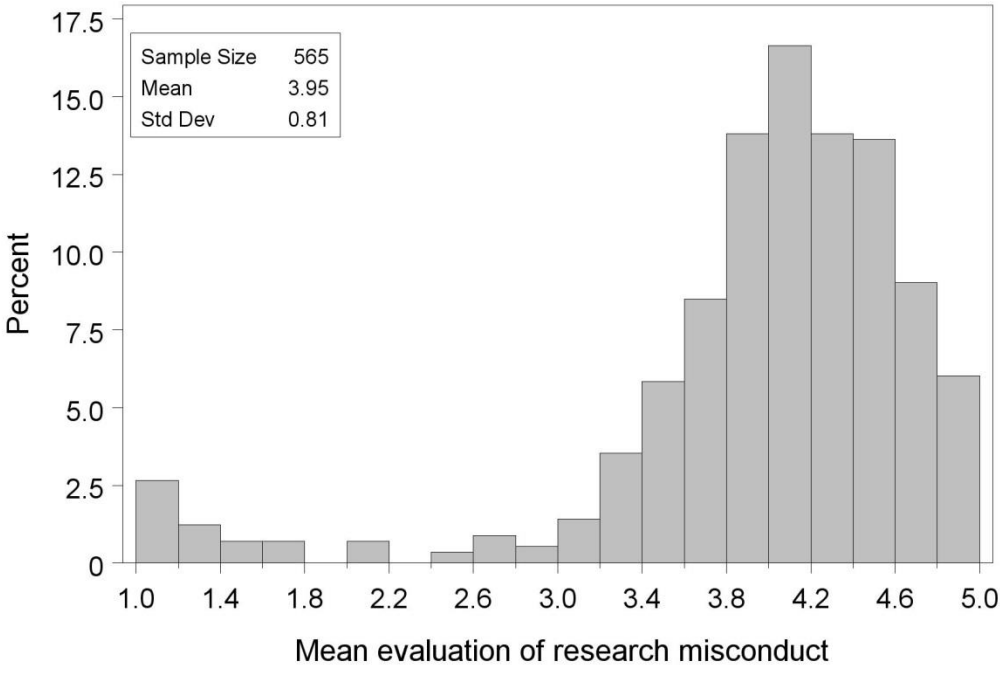

Table 1: Overview of information concerning predictors: universites versus industry.

	N(%) subjects with available information	Universities	Industry	P-value
Gender	636 (97%)			0.425
Female		46%	41%	
Male		54%	59%	
Age	634 (97%)			<0.001
Mean (SD)		38 (11)	44 (10)	
20-29		26%	4%	
30-39		36%	31%	
40-49		20%	39%	
>= 50		18%	26%	
Management level	656 (100%)			<0.001
Higher Management		26%	21%	
Middle Management		29%	34%	
Lower Management		15%	31%	
Not Applicable		30%	14%	
Obtained a degree outside Belgium	636 (97%)	23%	43%	<0.001
Obtained a PhD	636 (97%)	73%	70%	0.524
Mentorship[§]:	656 (100%)			
Help in developing professional relationships with others in your field		82%	70%	0.015

Assistance in writing for presentation and publication		94%	87%	0.029
Instruction in the details of good research practice		78%	76%	0.686
Continuing interest in your progress		93%	90%	0.387
Emotional support when needed		69%	55%	0.012
Help in learning the art of survival in your field		66%	53%	0.018
Assistance in obtaining financial support		85%	62%	<0.001
Research integrity training[§§]	641 (98%)			
Rather formal research integrity training				
A face-to-face classroom course focused specifically on research integrity		29%	34%	0.386
A section on research integrity within other courses in your field		35%	48%	0.025
Online course focused specifically on research integrity		14%	42%	<0.001
Rather informal research integrity training				
Workshops, conferences, roundtable discussions, etc.		45%	37%	0.138
Discussions with instructors, mentors, or colleagues		82%	81%	0.883
Aspects of 'general' moral character [§§§]				
Consider misconduct: Claim non existing credentials or work experience in the CV or the resume	639 (97%)	88%	82%	0.177
Consider misconduct: Unlawfully avoiding paying taxes.	639 (97%)	82%	83%	0.769
Taking something of minor or major value from the work place for personal use without paying for it.	638 (97%)			0.352
Considering stealing something of minor		7%	9%	

and major financial value as integrity				
Considering stealing something of minor value as integrity and stealing something of major value as misconduct		38%	31%	
Considering stealing something of minor and major financial value as misconduct		55%	60%	

[§] Some/a lot versus none
[§§] A great deal/some versus none
[§§§] Dichotomised 1-5 scale, ie. misconduct (4 or 5) versus no misconduct (scores 1-3).

Table 2: Comparison of the given scores between respondents active in universities and those active in industry of 22 actions of research misconduct (univariable), as well as a summary of the results from the multivariable models.

	Univariable									Multivariable model A		Multivariable model B	
	Universities				Industry					Difference Universities-Industry		Difference Universities-Industry	
Item	**1-2 (%)**	**3 (%)**	**4-5 (%)**	**Mean(SD)**	**1-2 (%)**	**3 (%)**	**4-5 (%)**	**Mean(SD)**	**P-value**	**(CI)**	**P-value**	**(CI)**	**P-value**
1. Unauthorized use of confidential information in connection with one's own research	6.4%	1.2%	92.4%	4.7 (1.0)	14.3%	4.4%	81.3%	4.4 (1.4)	0.0002	0.36 (0.11;0.61)	0.0044	0.23 (0.02;0.43)	0.0292
2. Changing the results or conclusions of a study in response to pressure from funding source	6.2%	1.4%	92.4%	4.6 (1.0)	15.4%	1.1%	83.5%	4.3 (1.4)	0.0286	0.32 (0.07;0.57)	0.0113	0.26 (0.04;0.47)	0.0193
3. Wilfully distorting research results or data (**falsification of data**)	6.2%	1.9%	91.9%	4.6 (1.0)	13.2%	4.4%	82.4%	4.3 (1.3)	0.0259	0.34 (0.10;0.59)	0.0063	0.20 (-0.00;0.40)	0.0516
4. Denying authorship credit to someone who has contributed substantively to a manuscript	7.8%	6.7%	85.5%	4.3 (1.1)	15.4%	9.9%	74.7%	4.0 (1.3)	0.0092	0.43 (0.16;0.69)	0.0018	0.34 (0.12;0.55)	0.0027
5. Using another's words, data or ideas without giving due credit (**plagiarism**)	7.4%	9.0%	83.5%	4.2 (1.0)	14.3%	15.4%	70.3%	3.8 (1.2)	0.0004	0.45 (0.19;0.70)	0.0006	0.41 (0.18;0.64)	0.0005

6. Inventing research data or cases (**fabrication of data**)	8.1%	9.9%	81.9%	4.2 (1.1)	14.3%	8.8%	76.9%	4.1 (1.3)	0.6096	0.14 (-0.13;0.41)	0.3018		
7. Publishing, as original research, ones previously published data or results	8.3%	9.7%	81.9%	4.2 (1.1)	15.4%	14.3%	70.3%	3.9 (1.4)	0.0823	0.34 (0.07;0.61)	0.0148	0.27 (0.03;0.50)	0.0275
8. Circumventing or ignoring aspects of human-subjects research requirements	9.7%	12.2%	78.1%	4.1 (1.1)	15.4%	5.5%	79.1%	4.1 (1.4)	0.4108	0.04 (-0.24;0.32)	0.7663		
9. Circumventing or ignoring aspects of animal-subjects research requirements	8.8%	13.1%	78.1%	4.1 (1.1)	16.5%	7.7%	75.8%	4.0 (1.3)	0.8554	0.14 (-0.14;0.41)	0.3300		
10. Not properly disclosing involvement in firms whose products are based on one's own research	9.2%	16.6%	74.2%	4.0 (1.1)	15.4%	12.1%	72.5%	3.8 (1.3)	0.7050	0.19 (-0.07;0.46)	0.1566		
11. Failing to present data that contradict one's own previous research	8.5%	18.9%	72.6%	3.9 (1.1)	15.4%	19.8%	64.8%	3.8 (1.3)	0.7562	0.19 (-0.08;0.45)	0.1655		
12. Knowingly overlooking others' use of flawed data or methods	9.2%	19.5%	71.3%	3.9 (1.1)	15.4%	12.1%	72.5%	3.8 (1.2)	0.6562	0.13 (-0.13;0.39)	0.3271		
13. Dropping observations or data points from analyses based on a gut feeling	12.4%	18.2%	69.4%	3.9 (1.1)	17.6%	18.7%	63.7%	3.7 (1.4)	0.9242	0.09 (-0.18;0.36)	0.5148		

14. Continued unintentional carelessness in conducting research	11.0%	19.1%	69.9%	3.9 (1.1)	16.5%	17.6%	65.9%	3.7 (1.3)	0.4164	0.22 (-0.04;0.49)	0.1008	0.17 (-0.07;0.40)	0.1584
15. Using inadequate or inappropriate research designs	9.9%	18.6%	71.5%	3.9 (1.1)	19.8%	17.6%	62.6%	3.6 (1.3)	0.2166	0.25 (-0.02;0.51)	0.0654	0.20 (-0.04;0.44)	0.1088
16. Cutting corners in a hurry to complete a project	9.4%	20.5%	70.1%	3.8 (1.0)	18.7%	20.9%	60.4%	3.5 (1.1)	0.0443	0.29 (0.05;0.54)	0.0188	0.21 (0.00;0.42)	0.0454
17.Circumventing or ignoring aspects of materials-handling requirements	15.4%	25.8%	58.8%	3.6 (1.1)	19.8%	9.9%	70.3%	3.7 (1.3)	0.1061	-0.08 (-0.36;0.20)	0.5711		
18. Withholding key aspects of methodology in papers or proposals	16.1%	31.5%	52.4%	3.5 (1.0)	16.5%	27.5%	56.0%	3.5 (1.1)	0.5959	0.06 (-0.19;0.31)	0.6449		
19. Inappropriate or careless review of papers or proposals	14.0%	30.1%	55.9%	3.5 (1.0)	23.1%	22.0%	54.9%	3.4 (1.2)	0.3934	0.19 (-0.06;0.44)	0.1316		
20. Inadequate record keeping or data management related to research projects	15.8%	31.0%	53.3%	3.4 (1.0)	19.8%	36.3%	44.0%	3.3 (1.1)	0.1837	0.15 (-0.10;0.40)	0.2430		
21. Giving authorship credit to someone who has not contributed substantively to a manuscript	20.5%	34.7%	44.8%	3.3 (1.1)	24.2%	25.3%	50.5%	3.4 (1.3)	0.6051	0.03 (-0.23;0.29)	0.8252		

22. Inadequate monitoring of research projects due to work overload	21.6%	38.6%	39.8%	3.2 (0.9)		24.2%	33.0%	42.9%	3.2 (1.1)		0.8658		0.07 (-0.17;0.30)	0.5810		
P-value univariable comparison (Mann-Whitney U test) of degree of qualifying an action as misconduct (1=integrity - 5= misconduct). CI: 95% confidence interval for the difference in mean ethical qualification. Model A= result from the multivariable model with correction for factors age, gender, obtained a PhD, obtained a degree abroad, and level of management. Model B=result from multivariable model considering all variables and applying a backward stepwise model selection. In the multivariable model B no odds ratio is reported for the difference in scores if this was not retained in the multivariable model. No multivariable models were fitted if the total number of events was lower than 10. The table ranges from the most serious forms of research misconduct according to the respondents to the least objectionable forms of research misconduct. Fabrication, falsification of data and plagiarism are in bold.															

Table 3: Overview of the relations between the admitted and observed actions of research misconduct and the ethical evaluation given to these 22 items of research misconduct.

Ethical qualification of individual actions	Admitted behavior			Observed behavior	
	Estimate (SE)	p		Estimate (SE)	p
1. Unauthorized use of confidential information in connection with one's own research					
2. Changing the results or conclusions of a study in response to pressure from funding source					
3. Wilfully distorting research results or data (**falsification of data**)					
4. Denying authorship credit to someone who has contributed substantively to a manuscript	-0.703 (SE=0.280)	0.0121			
5. Using another's words, data or ideas without giving due credit (**plagiarism**)	-0.941 (SE=0.191)	<.0001			
6. Inventing research data or cases (**fabrication of data**)					
7. Publishing, as original research, ones previously published data or results	-0.419 (SE=0.138)	0.0024			
8. Circumventing or ignoring aspects of human-subjects research requirements	-0.882 (SE=0.192)	<.0001			
9. Circumventing or ignoring aspects of animal-subjects research requirements	-0.766 (SE=0.248)	0.0020			
10. Not properly disclosing involvement in firms whose products are based on one's own research					
11. Failing to present data that contradict one's own previous research	-0.602 (SE=0.193)	0.0018			
12. Knowingly overlooking others' use of flawed data or methods	-0.723 (SE=0.162)	<.0001			

13. Dropping observations or data points from analyses based on a gut feeling	-1.077 (SE=0.108)	<.0001			
14. Continued unintentional carelessness in conducting research	-0.860 (SE=0.305)	0.0048			
15. Using inadequate or inappropriate research designs					
16. Cutting corners in a hurry to complete a project	-0.467 (SE=0.109)	<.0001			
17.Circumventing or ignoring aspects of materials-handling requirements	-0.812 (SE=0.130)	<.0001			
18. Withholding key aspects of methodology in papers or proposals					
19. Inappropriate or careless review of papers or proposals	-0.530 (SE=0.203)	0.0089		-0.226 (SE=0.090)	0.0125
20. Inadequate record keeping or data management related to research projects	-0.191 (SE=0.085)	0.0253			
21. Giving authorship credit to someone who has not contributed substantively to a manuscript	-0.541 (SE=0.090)	<.0001		0.163 (SE=0.100)	0.1047
22. Inadequate monitoring of research projects due to work overload	-0.334 (SE=0.074)	<.0001			
Results from the multivariable models obtained after backward stepwise selection (model B). Note that results are only given when the variable is retained in the model. Results from an additive multivariable linear regression model, obtained after multiple imputation (10 datasets). If selected (S) and (C) refer to reported behavior for self and colleagues, respectively.					

Supplementary appendix

Table 4: Overview of relations between lying, stealing and cheating and the ethical evaluation of the 22 items of research misconduct.

	Lying (Claim non existing credentials or work experience in the curriculum vitae or the resume.)		**Cheating** (Unlawfully avoiding paying taxes.)		**Stealing** (Taking something of financial value from the work for personal without paying for it.**)				
						Minor and major=integrity		Minor and major=misconduct	
	Estimate (SE)	p	Estimate (SE)	p	Overall p	Estimate (SE)	p	Estimate (SE)	p
1. Unauthorized use of confidential information	0.746 (SE=0.118)	<.0001	0.186 (SE=0.108)	0.085	<.0001	-1.219 (SE=0.177)	<.0001	-0.206 (SE=0.077)	0.007
2. Changing the results or conclusions	0.604 (SE=0.122)	<.0001	0.278 (SE=0.112)	0.014	<.0001	-1.117 (SE=0.183)	<.0001	-0.134 (SE=0.081)	0.098
3. Wilfully distorting research results or data	0.688 (SE=0.117)	<.0001	0.252 (SE=0.108)	0.020	<.0001	-1.101 (SE=0.177)	<.0001	-0.110 (SE=0.077)	0.151
4. Denying authorship credit	0.744 (SE=0.130)	<.0001	0.261 (SE=0.118)	0.028	<.0001	-1.050 (SE=0.193)	<.0001	0.122 (SE=0.085)	0.150
5. Using another's words, data or ideas	0.716 (SE=0.129)	<.0001	0.234 (SE=0.118)	0.046	<.0001	-0.886 (SE=0.189)	<.0001	0.035 (SE=0.085)	0.675
6. Inventing research data or cases	0.566 (SE=0.132)	<.0001	0.346 (SE=0.122)	0.005	<.0001	-1.064 (SE=0.196)	<.0001	0.162 (SE=0.085)	0.058
7. Publishing ones previously published	0.682 (SE=0.135)	<.0001	0.279 (SE=0.125)	0.026	<.0001	-0.986 (SE=0.199)	<.0001	0.072 (SE=0.089)	0.422
8. Circumventing human-subjects requirements	0.462 (SE=0.138)	0.001	0.380 (SE=0.129)	0.003	<.0001	-1.138 (SE=0.205)	<.0001	0.144 (SE=0.090)	0.110
9. Circumventing animal-subjects requirements	0.379 (SE=0.138)	0.006	0.505 (SE=0.127)	<.0001	<.0001	-0.852 (SE=0.202)	<.0001	0.138 (SE=0.091)	0.130
10. Not properly disclosing involvement	0.613 (SE=0.132)	<.0001	0.306 (SE=0.121)	0.011	<.0001	-0.928 (SE=0.196)	<.0001	0.246 (SE=0.086)	0.004
11. Failing to present data	0.549 (SE=0.132)	<.0001	0.260 (SE=0.121)	0.032	<.0001	-1.006 (SE=0.195)	<.0001	0.063 (SE=0.086)	0.462
12. Overlooking others' use of flawed data or methods	0.490 (SE=0.128)	0.0001	0.185 (SE=0.119)	0.121	<.0001	-0.969 (SE=0.193)	<.0001	0.259 (SE=0.084)	0.002
13. Dropping observations or data points	0.424 (SE=0.137)	0.002			<.0001	-1.071 (SE=0.187)	<.0001	0.283 (SE=0.087)	0.001
14. Continued unintentional carelessness	0.546 (SE=0.132)	<.0001	0.218 (SE=0.122)	0.074	<.0001	-1.089 (SE=0.198)	<.0001	0.124 (SE=0.088)	0.158
15. Using inadequate research designs	0.597 (SE=0.135)	<.0001			<.0001	-0.985 (SE=0.183)	<.0001	0.196 (SE=0.087)	0.025
16. Cutting corners in a hurry to complete a project	0.467 (SE=0.123)	<0.001			<.0001	-0.953 (SE=0.167)	<.0001	0.233 (SE=0.079)	0.003
17. Circumventing materials-handling requirements	0.347 (SE=0.141)	0.014	0.262 (SE=0.130)	0.045	<.0001	-0.875 (SE=0.206)	<.0001	0.248 (SE=0.091)	0.007
18. Withholding key aspects of methodology	0.437 (SE=0.127)	0.001	0.217 (SE=0.118)	0.066	<.0001	-0.417 (SE=0.191)	0.029	0.399 (SE=0.085)	<.0001
19. Inappropriate or careless review	0.288 (SE=0.126)	0.023	0.186 (SE=0.117)	0.111	<.0001	-0.945 (SE=0.186)	<.0001	0.216 (SE=0.083)	0.009
20. Inadequate record keeping or data management	0.441 (SE=0.127)	0.001	0.240 (SE=0.116)	0.039	<.0001	-0.629 (SE=0.185)	0.001	0.258 (SE=0.083)	0.002
21. Gift authorship	0.428 (SE=0.136)	0.002	0.390 (SE=0.125)	0.002	0.002	-0.271 (SE=0.198)	0.172	0.281 (SE=0.089)	0.002
22. Inadequate monitoring of research projects					<.0001	-0.637 (SE=0.150)	<.0001	0.353 (SE=0.077)	<.0001
Results from the multivariable models obtained after backward stepwise selection (model B). Note that results are only given when the variable is retained in the model. The 22 items listed were abbreviated. The full description of the items can be seen in Tables 2 and 3.									

Table 5: Detailed overview of relations between several predictors and the ethical evaluation of the 22 items of research misconduct.

	Work context*		Gender**		Age***							Degree			
						20-29		30-39		40-49		Obtained outside Belgium		Obtained a PhD	
	Estimate (SE)	p	Estimate (SE)	p	Overall p	Estimate (SE)	p	Estimate (SE)	p	Estimate (SE)	p	Estimate (SE)	p	Estimate (SE)	p
1. Unauthorized use of confidential information	-0.225 (SE=0.103)	0.029										-0.218 (SE=0.082)	0.008		
2. Changing the results or conclusions	-0.257 (SE=0.110)	0.019			0.025	-0.162 (SE=0.120)	0.176	0.146 (SE=0.106)	0.169	0.033 (SE=0.114)	0.776	-0.246 (SE=0.086)	0.004		
3. Wilfully distorting research results or data	-0.201 (SE=0.103)	0.052										-0.180 (SE=0.082)	0.029		
4. Denying authorship credit	-0.335 (SE=0.112)	0.003												-0.171 (SE=0.089)	0.055
5. Using another's words, data or ideas	-0.408 (SE=0.116)	0.001			0.123	-0.166 (SE=0.159)	0.296	0.145 (SE=0.110)	0.188	0.061 (SE=0.118)	0.606	-0.161 (SE=0.090)	0.075	-0.242 (SE=0.124)	0.052
6. Inventing research data or cases												-0.176 (SE=0.091)	0.054		
7. Publishing ones previously published	-0.266 (SE=0.121)	0.028			0.055	-0.186 (SE=0.131)	0.155	0.045 (SE=0.116)	0.696	0.145 (SE=0.127)	0.252	-0.259 (SE=0.096)	0.007		
8. Circumventing human-subjects requirements												-0.142 (SE=0.096)	0.136		
9. Circumventing animal-subjects requirements					0.068	-0.081 (SE=0.171)	0.638	0.241 (SE=0.119)	0.044	0.169 (SE=0.129)	0.189	-0.186 (SE=0.096)	0.053	-0.209 (SE=0.134)	0.119
10. Not properly disclosing involvement															
11. Failing to present data												-0.201 (SE=0.091)	0.027		
12. Overlooking others' use of flawed data or methods												-0.163 (SE=0.090)	0.071		
13. Dropping observations or data points												-0.213 (SE=0.094)	0.024		
14. Continued unintentional carelessness	-0.167 (SE=0.118)	0.158			0.109	-0.268 (SE=0.130)	0.040	-0.109 (SE=0.114)	0.339	0.000 (SE=0.124)	0.997				
15. Using inadequate research designs	-0.199 (SE=0.124)	0.109			0.119	-0.325 (SE=0.170)	0.056	0.021 (SE=0.117)	0.857	-0.064 (SE=0.126)	0.611	-0.172 (SE=0.095)	0.071	-0.223 (SE=0.133)	0.093
16. Cutting corners in a hurry to complete a project	-0.214 (SE=0.107)	0.045													
17. Circumventing materials-handling requirements															
18. Withholding key aspects of methodology															
19. Inappropriate or careless review														-0.155 (SE=0.087)	0.075
20. Inadequate record keeping or data management			-0.147 (SE=0.077)	0.054								-0.134 (SE=0.087)	0.123		
21. Gift authorship														-0.209 (SE=0.094)	0.026
22. Inadequate monitoring of research projects			-0.263 (SE=0.073)	0.001											

Results from the multivariable models obtained after backward stepwise selection (model B). Note that results are only given when the variable is retained in the model.

The 22 items listed were abbreviated. The full description of the items can be seen in Tables 2 and 3.

* Negative estmate refers to higher score in university

** Negative estmate refers to higher score for females

***Reference category was ≥ 50 years.

Table 6: Overview of the relations between received training and the ethical evaluation of the 22 items of research misconduct.

	Research integrity training									
	Informal research integrity training				Formal research integrity training					
	Workshops, conferences, roundtable discussions, etc.		Discussions with instructors, mentors, or colleagues		A section on research integrity within other courses in your field		A face-to-face classroom course focused specifically on research integrity		Instruction in the details of good research practice	
	Estimate (SE)	p	Estimate (SE)	p	Estimate (SE)	p	Estimate (SE)	p	Estimate (SE)	p
1. Unauthorized use of confidential information							-0.160 (SE=0.079)	0.042	-0.133 (SE=0.087)	0.126
2. Changing the results or conclusions							-0.133 (SE=0.082)	0.105		
3. Wilfully distorting research results or data							-0.188 (SE=0.078)	0.016		
4. Denying authorship credit							-0.189 (SE=0.086)	0.029		
5. Using another's words, data or ideas			0.226 (SE=0.100)	0.024			-0.129 (SE=0.085)	0.131		
6. Inventing research data or cases							-0.166 (SE=0.086)	0.053		
7. Publishing ones previously published					-0.133 (SE=0.085)	0.117				
8. Circumventing human-subjects requirements	0.183 (SE=0.084)	0.030								
9. Circumventing animal-subjects requirements										
10. Not properly disclosing involvement			0.187 (SE=0.102)	0.066						
11. Failing to present data	0.139 (SE=0.082)	0.092	0.210 (SE=0.107)	0.048						
12. Overlooking others' use of flawed data or methods	0.149 (SE=0.083)	0.073			-0.166 (SE=0.086)	0.054				
13. Dropping observations or data points	0.197 (SE=0.083)	0.017								
14. Continued unintentional carelessness	0.154 (SE=0.086)	0.074			-0.138 (SE=0.089)	0.121				
15. Using inadequate research designs	0.203 (SE=0.088)	0.021			-0.170 (SE=0.091)	0.061				
16. Cutting corners in a hurry to complete a project										
17. Circumventing materials-handling requirements										
18. Withholding key aspects of methodology										
19. Inappropriate or careless review	0.200 (SE=0.077)	0.009							0.138 (SE=0.095)	0.146
20. Inadequate record keeping or data management	0.128 (SE=0.077)	0.094								
21. Gift authorship			0.174 (SE=0.107)	0.105						
22. Inadequate monitoring of research projects										
Results from the multivariable models obtained after backward stepwise selection (model B). Note that results are only given when the variable is retained in the model. The 22 items listed were abbreviated. The full description of the items can be seen in Tables 2 and 3.										

Table 7: Overview of the relations between received mentoring and the ethical evaluation of the 22 items of research misconduct

	Mentorship									
	Continuing interest in your progress		Emotional support when needed		Assistance in writing for presentation and publication		Help in learning the art of survival in your field		Help in developing professional relationships with others in your field	
	Estimate (SE)	p	Estimate (SE)	p	Estimate (SE)	p	Estimate (SE)	p	Estimate (SE)	p
1. Unauthorized use of confidential information									0.227 (SE=0.091)	0.013
2. Changing the results or conclusions			-0.119 (SE=0.079)	0.134					0.182 (SE=0.094)	0.054
3. Wilfully distorting research results or data							-0.129 (SE=0.078)	0.010	0.235 (SE=0.094)	0.013
4. Denying authorship credit							-0.183 (SE=0.081)	0.024		
5. Using another's words, data or ideas							-0.195 (SE=0.081)	0.016		
6. Inventing research data or cases	-0.263 (SE=0.153)	0.086							0.203 (SE=0.102)	0.046
7. Publishing ones previously published										
8. Circumventing human-subjects requirements							-0.173 (SE=0.087)	0.046		
9. Circumventing animal-subjects requirements							-0.177 (SE=0.091)	0.051	0.192 (SE=0.109)	0.078
10. Not properly disclosing involvement										
11. Failing to present data			-0.153 (SE=0.085)	0.074						
12. Overlooking others' use of flawed data or methods										
13. Dropping observations or data points					-0.271 (SE=0.161)	0.093			0.214 (SE=0.106)	0.044
14. Continued unintentional carelessness										
15. Using inadequate research designs					-0.284 (SE=0.158)	0.072	-0.133 (SE=0.089)	0.137	0.156 (SE=0.109)	0.154
16. Cutting corners in a hurry to complete a project									0.156 (SE=0.093)	0.093
17. Circumventing materials-handling requirements					-0.307 (SE=0.160)	0.055				
18. Withholding key aspects of methodology										
19. Inappropriate or careless review							-0.154 (SE=0.087)	0.077	0.159 (SE=0.102)	0.119
20. Inadequate record keeping or data management					-0.203 (SE=0.144)	0.159				
21. Gift authorship							-0.168 (SE=0.086)	0.051		
22. Inadequate monitoring of research projects	0.228 (SE=0.143)	0.110					-0.153 (SE=0.079)	0.052		

Results from the multivariable models obtained after backward stepwise selection (model B). Note that results are only given when the variable is retained in the model.
The 22 items listed were abbreviated. The full description of the items can be seen in Tables 2 and 3.

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Phase three:

Concluding ethical implications concerning the elaboration of a research integrity policy

Introduction

As anticipated in the introduction of this PhD thesis, due to our empirical ethics approach, our research provided novel data about various elements concerning research integrity and misconduct within biomedical research. By reviewing the guidance documents we gained insight into the theoretical ethical frameworks concerning research integrity and misconduct from a policy perspective. Throughout our empirical studies we investigated, among other elements, whether the self-reported research conduct and ethical evaluation of research misconduct of biomedical researchers and research managers, active in universities or industry, were in line with these theoretical ethical frameworks. Due to the analysis of these empirical data, we made this ethical evaluation more explicit. Based on the findings of our research, we formulate concluding ethical implications concerning the elaboration of a research integrity policy and three recommendations.

In the first phase of our research we found differences concerning several elements, including the stimulating factors towards, the harmful impact of, and even the definition of research misconduct within the European guidance documents on research integrity.[1-3] In addition, our studies proved that there was an apparent variety across Europe concerning regulatory research integrity systems. When observing the map of Europe which provides an overview of the various research integrity policies, a general distinction could be made between more northern and more southern countries.[1] In the northern part of Europe,

it was more common to have a national framework, sometimes established by law, that concerns itself with the issues of research integrity or misconduct, compared to southern Europe. On top of these differences, the guidance documents were very difficult to access.

Our empirical studies demonstrated several new findings.[4-6] Both our empirical studies showed that the ethical evaluation of research misconduct by biomedical researchers and research managers was not in line with that of the (inter)national research integrity guidance. In addition, various strategies were implemented to stimulate research integrity or to deal with research misconduct within industry and universities. Our survey demonstrated that the prevalence of self-reported admitted and observed research misconduct is substantial in both universities and industry. Overall, research misconduct was reported less within industry compared to universities. Nevertheless, significantly more participants within industry reportedly observed plagiarism being conducted by their colleagues, compared to universities.

We showed that (formal and informal) research integrity training is related to the reporting and the ethical evaluation of research misconduct. Our findings are in line with the idea that elaborating research integrity training is an important element of an effective research integrity policy.[7-10] The evolution research integrity training has gone through since the previous USA study might explain why our study provides a different outcome compared to previous studies.[11] Our results also showed that research integrity training has various relations on the reporting and ethical evaluation of research misconduct, depending on its format and approach. We might

hypothesize that formal research integrity training stimulates the awareness of and the compliance towards the norms of research integrity and misconduct. Biomedical researchers and research managers who participated at such training, therefore, will no longer conduct certain actions because they learned those actions are not tolerated and will be sanctioned. However, what they themselves consider to be (un)acceptable might differ from these norms. Informal research integrity training might operate rather on the level of values concerning research integrity. Hereby the focus of this kind of training is to let biomedical researchers and research managers incorporate the principles of research integrity.

The majority of respondents of our survey believed that implementing a guideline would strongly help to prevent research misconduct. This indicates that a thorough communication concerning the national and international research integrity guidelines is vital, but nonetheless currently insufficient. However, the apparent diversities and the difficulty of coming to a harmonized research integrity guidance underline the importance of distinguishing between a value- and norm-based approach when elaborating a research integrity policy.[3]

On the one hand, a one-sided focus on a norm-based approach can result in a culture of fear: fear for sanctions, fear for collateral damage when being associated with someone who is suspected of research misconduct. Important research values such as transparency and honesty come under pressure. Additionally, due to the continuous evolution of science, norms and standards may be outdated quickly. The continuous development of new technologies requires a constant

evaluation of the norms and standards. Also cultural differences may result in heterogeneous norms which co-exist at the same time. On the other hand, a one-sided focus on a value-based approach can create a culture where people get away with questionable research practice and even serious misconduct by not imposing clear sanctions.

These norm- and value-based approaches are not mutually exclusive. An emphasis on values and a culture that shows in its daily practice it treasures these values can be supported by an overview of the norms concerning research behavior. Clear norms and rules might help researchers to balance their conduct. A policy rooted in values shared by for example the biomedical researchers and research managers, forms a basis on which norms can be elaborated. If the situation changes, due to technological developments, the norms can be altered. The values however, which ideally are interiorized by the biomedical researchers and research managers, provide a continuous and sustainable point of reference.

On top of the heterogeneity concerning research integrity guidance in Europe, the disagreement between the research integrity guidance and the biomedical researchers and research managers concerning the definition of research misconduct is striking. A possible interpretation of this disagreement is that respondents are not closely familiar with the concept of fabrication of data as used by the research integrity guidance. Therefore they might consider this action to be a serious form of research misconduct, however, not as serious as falsification of research. A stronger familiarity with the research integrity

guidance, that clearly condemns fabrication of data, might result in a more rigorous attitude towards fabrication of data.

Another possible interpretation is that the current research integrity guidance is developed without sufficiently consulting or involving biomedical researchers and research managers, active in industry or academia. Therefore, the guidance is oriented top-down, instead of bottom-up, resulting in a guidance that is perceived as a '*corpus alienum*'. Hereby, biomedical researchers and research managers might have to abide by certain norms and values, although they themselves uphold different perspectives on research integrity and misconduct. When combining this interpretation with the fact that the national guideline of Belgium is mostly unknown, one might conclude that the current research integrity guidance has no or little impact in the reality of daily research practice.

Recommendations

In order to progress out of the situation of heterogeneity and contradictory views, we refer to the earlier discussed continuous cyclic interaction between research integrity guidance and the data received from the daily praxis, combined with a consideration of the specificity of the context of biomedical research. Based on our research findings, we advocate that the perspectives of biomedical researchers and research managers should be involved throughout this process. If they would not be involved, we risk to end up with a policy that is not acknowledged and shared by those professionals that actually conduct biomedical research. As stated earlier, this research integrity policy needs to balance the earlier mentioned differences between a norm- and value-based approach. Based on shared values and a universal and generally accepted understanding of research integrity, norms concerning research misconduct can be developed, given that this should be a dynamic process which needs to be continuously updated in correspondence with the evolution of science.

We formulate three recommendations which can be valuable tools in order to create and sustain the earlier mentioned continuous cyclic interaction between research integrity guidance and the data received from the daily praxis. In line with our approach of empirical ethics, which adheres much importance to the praxis, we also want to consider those elements and procedures that are of importance when conducting research: the role of the funders, research organizations,

publishers and journals. We plead for a combined approach, because there is not one fixed answer to these complicated questions.

Reevaluating research integrity guidance

Our findings indicate that there is room for improvement of the awareness and accessibility of the current research integrity guidance as well as the alignment of its perspectives with those of biomedical researchers and managers themselves. The fact that biomedical researchers and research managers upheld a similar ranking of the research misconduct actions (most serious to least objectionable) might provide a foundation on which the current research integrity guidance can be reevaluated in order to create a more balanced and agreed upon research integrity policy. Taking the perspectives and attitudes of biomedical researchers and research managers into account when developing a research integrity guidance document will provide the guidance with an empirical foundation.

Additionally, the accessibility of the research integrity guidance should be optimized. When biomedical researchers and research managers are faced with problems or have questions concerning research integrity and misconduct, they should have easy access to the relevant documents. Guidance that is not easily accessible for researchers will most likely only have limited impact on the actual daily practice of researchers.

In line with other authors,[12-14] we hypothesize that journals and publishers can play a vital role in stimulating research integrity and demanding that biomedical researchers abide by certain rules,

methodologies and procedures. The Committee on Publication Ethics, as well as the International Committee of Medical Journal Editors, provide a unique point of reference for journals.[15-16] We believe that also funding agencies should play a role. Funding as well as publishing research is important for the existence and progression of biomedical research. Therefore, a policy concerning research integrity which is supported and enforced by the journals, publishers, and funders, and which is accessible and visible, might help to prevent research misconduct and stimulate research integrity. The Belgian funding agencies FWO and FNRS for example, have dedicated substantial attention to research integrity.[17-18]

Elaborating research integrity training

In a comment in *Science* we discussed that there is no harmonized strategy concerning research integrity training within the research integrity guidance documents[1]:

> "Most guidance documents propose, without providing much detail, that education in good research practices should be part of research training. However, there is no consensus across Europe about the content, format, timing, or frequency of such courses, nor is there a common view on who needs training and who qualifies to lead the training. What level of student or researcher should training target? What kind of training could help professors, who heavily influence the culture in which their researchers work?[2] Is there evidence that training adults promotes integrity or prevents dishonest behavior in other areas of life?"[1]

As previous research has showed, supervisors and mentors have a strong responsibility concerning the prevention of research misconduct.[19] Therefore, we plea for providing continuous and varied research integrity training for all biomedical researchers and managers, including senior researchers. Professors and supervisors create and maintain the research culture of their research group. They determine the norms, standards and principles by which their co-workers and junior researchers abide. This process happens both explicitly and implicitly. Senior researchers provide practical research integrity guidance by their own conduct, but also by encouraging, sanctioning, or ignoring certain actions and behaviors. They show what the value of honesty for example concretely means in the daily practice. Professors and supervisors have a strong influence on the elaboration of a culture of research integrity. Such a culture might attract and cultivate researchers and research managers whom adhere to research integrity.

Elaborating such research integrity training within research organizations will also help raising awareness and reflection concerning the issues of research integrity and misconduct. Additionally, also the international and national European guidance documents on research integrity most frequently mention research integrity training in order to prevent research misconduct. Our survey demonstrated the relations of formal and informal research integrity training with reporting and ethically evaluating research misconduct. Similarly to the norm- and value-based approach underlying the research integrity guidance documents, both approaches are not mutually exclusive. Combining formal with informal research integrity training might help to balance the

focus on norm compliance towards research misconduct, with the incorporation of the values of research integrity.

Research integrity policy, including research integrity training, has been elaborated in several research organizations in Belgium. However, to date research integrity training is not an obligatory requirement when applying for a research funding in Belgium, which is the case in the USA with the National Institute of Health and the National Science Foundation.[21-22] Such a requirement might ensure that also senior research follow research integrity training.

In addition, within Flanders, the Flemish Commission for Research Integrity (VCWI) was established in 2013.[20] In total, 17 organizations are affiliated with the VCWI. The procedure, in brief, is as follows: first, a decision is made at the level of the institution by a commission that deals with research misconduct allegations (in most organizations affiliated with the VCWI, such a commission is named "Commission on Research Integrity"). All parties involved are informed about the decision. The parties involved might challenge this decision. After a decision has been made at the level of the institution by a commission that deals with research misconduct allegations, the VCWI might be asked to provide a second opinion.

Confidential advisors

Our qualitative study showed that within certain international biomedical companies, a network of confidential advisors was created.[4] This implies that when biomedical researchers or research managers are confronted with questions or difficulties concerning research inte-

grity or misconduct, they can discuss these issues in confidence with an advisor. These advisors operate independently from the commission that deals with allegations of research misconduct. It might however be possible that the advisor would stimulate a consulter to report a specific allegation to this commission.

By putting the emphasis mainly on a norm-based approach, by for example solely focusing on the commissions to deal with allegations of research misconduct and the possible sanctions, biomedical researchers and research managers might feel restrained to step forward when observing research misconduct. This hypothesis is in line with the findings of our quantitative study, which showed that almost 50% of the biomedical researchers and research managers within universities was not willing to report a case of research misconduct, compared to 21% within industry.[5] In such a context, fear of retribution or association might overcome the imperative to report research misconduct.

Elaborating a system were confidential advisors can be consulted within research organizations, however, might stimulate a culture where a normative approach of compliance with the rules is balanced with a culture of trust and a focus on values and transparency. This will help to develop and maintain a research culture where acting with integrity is the spontaneous, natural way to conduct research.

Limitations and further research

This PhD research had several limitations, which have been discussed in the various chapters of this PhD thesis (p. 39–40, p. 112–113, p. 140–142; p. 177). Our survey for example was cross-sectional, with relatively small samples, especially for industry. Often, organizations within industry chose to distribute the survey to a rather small sample within their organization. We also relied on the self-reporting of our respondents. Admittedly, this approach does not provide a solid base to investigate the actual behavior concerning research misconduct. We also performed a multitude of tests. However, as stated on p. 135-136 (Phase 2 chapter 2) we only considered p-values smaller than 0.01 (instead of the classical 0.05) as significant.

When this PhD research started in 2011, little was known about various aspects of the topics we wished to investigate. No overview and no comparative analysis of the integrity guidance documents of the countries of the European Union (EU) and European Free Trade Association (EFTA) existed. Similarly, it was uncertain what the perspectives were of biomedical researchers and research managers active in industry and whether these differed from biomedical researchers and research managers active in universities. Therefore, a more exploratory approach was chosen.

Based on research findings concerning the impact of research integrity training on both the reported frequency as well as the ethical evaluation of research misconduct, we suggest to dedicate further re-

search on the possible influence and desired format of research integrity training.

We also suggest to investigate how transparent the commissions or offices that deal with research misconduct operate, and whether for example publishing their (anonymized) reports might be desirable. In order to deal with allegations of research misconduct, commissions or offices of research integrity have been created all over the world. Depending on the situation, these commissions are organized within one institution, or even have a national oversight. Internationally, various practices exist concerning the publishing of the reports of the discussed allegations of research misconduct. The USA Office of Research Integrity for example publishes in her report the name of the accused, and the organization were he or she worked when the research misconduct took place.[23]

We hypothesize that by publishing the reports the commissions might demonstrate more explicitly how they deal with allegations of research misconduct and what they consider to be (un)acceptable. Transparency concerning their judgment, and possible imposed sanctions, demonstrate their visions of what is to be considered research misconduct or merely questionable research practices. These reports can therefore help to clarify not only the definition of research misconduct, but also the position of the organization towards rather questionable research practices that are not considered as severe as research misconduct but might also be unacceptable. In addition, publishing these reports might also demonstrate the emphasis the commissions put on certain aspects during their ethical evaluation of

cases. Do they focus on the kind of action that was committed, or whether or not the action was committed with the intention to deceive, or do they underline the possible consequences? The chosen focus on one or a combination of the previous mentioned elements, will affect the ethical evaluation of the action. If we emphasize the consequences for example, biomedical researchers might consider the plagiarism of texts less harmful than falsifying research data because less harm is done.

Throughout the process of research, there is also a role for the ethics committees. The Belgian law on human experiments stipulates that before an experiment can be conducted, a "positive advice" of an ethic committee is required.[24] One might ask whether such committees have a role concerning dealing with research misconduct allegations. The law describes the various elements on which the ethics committees must reflect, for example whether or not the sufficient and adequate written information is provided to the research subjects in order for them to make an informed decision concerning participation. Research integrity and research misconduct are not (explicitly) enlisted in those elements. No empirical data exists on whether these committees have dealt with research misconduct allegations and, if so, what procedures they followed. If they take up this role, it remains unclear what the relations are or should be between the local ethics committees and local, regional or national commissions explicitly installed for dealing with research misconduct allegations. Universities in Flanders have both kinds of commissions and are affiliated with the VCWI, however general hospitals for example generally only have

an ethics committee. Further research into this domain might provide interesting information.

Conclusion

This PhD research had several limitations, which are often already discussed in the various articles. Due to these limitations, we are prudent in making claims based on our research. Our research showed that various factors influence the conduct of biomedical researchers and research managers concerning research integrity or misconduct. The earlier mentioned continuous cyclic interaction, stimulated by our three proposed recommendations, is needed for an agreed upon and sustainable research integrity policy. The process of elaborating a research integrity policy is continuous and dynamic because research itself is constantly evolving. It does not end when a new research integrity guideline is developed. It should be open to new evolutions in science and influences from other aspects of the policy, for example the commissions that deal with research misconduct allegations or research integrity training. Based on a clear and agreed upon overview of common and fundamental values concerning research integrity, norms can be developed and continuously updated.

Our three proposed recommendations impact and stimulate each other. Elaborating research integrity training will familiarize biomedical researchers and research managers with the research integrity guidance. It will also impact the continuous process of re-evaluation of this guidance. This whole system requires a culture of trust, for which installing a network of confidential advisors is a primary step. This dynamic, stimulated by the three proposed recommendations,

will form a basis for a research culture of trust, which balances the norm- and value-based approach.

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Miscellaneous

An abstract of the research

The issues of research integrity and misconduct feature regularly in academic journals and the press. Misconduct within biomedical research is harmful because it threatens the excellence and progression of biomedical research. It can lead for example to wrong medication and damages trust, both the public's trust in biomedical research and the mutual trust of biomedical researchers. Biomedical research is increasingly interdisciplinary and international. Therefore a breach in trust has a huge impact.

The objectives of our research are to tackle the three following main research goals:

- Comprehensive retrieval and comparative analysis of the research integrity guidance documents of the countries belonging to the European Union (EU) and European Free Trade Association (EFTA).
- Analyzing the perspectives, attitudes, behaviors, and ethical evaluation concerning research integrity and misconduct of biomedical researchers and research managers, active in universities or industry.
- Reflecting on the elaboration of a research integrity policy from an ethical perspective.

We opted for an empirical ethics approach. Therefore, the project consists of three phases. In the first phase, a review is made of the official guidance documents on research integrity to map the different policies and strategies towards research integrity guidance within the European economic area. Secondly, both a qualitative and a quantitative study are conducted among biomedical researchers and research managers active within academia and industry. These empirical studies aimed to gauge their perspectives, knowledge and attitudes towards the issues of research integrity and misconduct. Finally, we brought the two previous phases together in a reflection about the concluding ethical implications concerning the elaboration of a research integrity policy.

Our research provided several novel findings. There was heterogeneity between the research integrity guidance documents in Europe concerning various elements, including how research misconduct ought to be defined. Within Europe, various systems were implemented. In northern Europe, it was common to have a national commission to deal with research misconduct allegations. Whereas in southern Europe, no such national commissions existed. In addition, it was often challenging to access the research integrity guidance documents.

Research misconduct occurred to a substantial degree in both universities and industry. Industry and universities upheld different strategies towards research integrity and misconduct. Our analysis revealed several relations with various factors concerning issues of research integrity and misconduct, and the abstract concept of "research integrity" gained a realistic, empirically-based meaning. The

ethical evaluation towards research misconduct differed between biomedical research and research managers on the one hand, and research integrity guidance documents in the other hand. The reported frequency of research misconduct related with research integrity training and the ethical evaluation of the listed items of research misconduct.

Based on our research findings, we formulated several recommendations in order to stimulate an agreed upon research integrity policy. We aim to achieve an agreed upon research integrity policy by creating and maintaining a continuous and cyclic interaction between empirical data and research integrity guidance documents. When evaluating a research integrity policy, the perspectives and challenges of biomedical researchers and research managers need to be taken into consideration, within the framework of foundational research integrity principles.

Academic career

List of publications

Articles in internationally reviewed academic journals

Godecharle S., Fieuws S., Nemery B., Dierickx K. (2017). Scientists Still Behaving Badly? A Survey Within Industry and Universities. *Science and Engineering Ethics*, doi: 10.1007/s11948-017-9957-4.

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Stroobants K., Godecharle S., Brouwers S. (2013). Flanders overrates impact factors. *Nature, 500* (7460), 29.

Articles in other academic journals

Godecharle S. (2014). Symposium report: Research fraud & integrity: what can and should be done?. *Ethische Perspectieven: Nieuwsbrief van het Overlegcentrum voor Ethiek, 24* (3), 275–282.

Presentations at (international) scientific and other professionally oriented conferences and symposia

Meeting abstracts, presented at international scientific conferences and symposia, published or not published in proceedings or journals

Godecharle S. (2017). Elaborating a policy concerning ethics: role of caregivers. Present and Future Challenges and Opportunities for Ethics in Nursing and Care. KU Leuven, 15-16 September 2017.

Godecharle S. (2017). Chair of session ‘Interventions to support ethics in care’. Present and Future Challenges and Opportunities for Ethics in Nursing and Care. KU Leuven, 15-16 September 2017.

Godecharle S., Nemery B., Dierickx K. (2015). Research integrity management: Empirical investigation of academia versus industry. 4th World Conference on Research Integrity. Rio de Janeiro (Brazil), 31 May - 3 June 2015.

Godecharle S. (2015). Invited to chair the session: “Are there country-specific elements of misconduct?”. 4th World Conference on Research Integrity. Rio de Janeiro (Brazil), 31 May - 3 June 2015.

Godecharle S., Nemery B., Dierickx K. (2014). Verschillende stelsels en strategieën omtrent wetenschappelijke integriteit in Europa. LOWI Seminar 2014. Amsterdam (the Netherlands), 26 November 2014.

Godecharle S., Nemery B., Dierickx K. (2014). Responsible Conduct of Research: Policies and Strategies. UM Days on Research Ethics. Maastricht University (The Netherlands), 12 November 2014.

Godecharle S., Nemery B., Dierickx K. (2014). Research integrity guidance and training. Developing educational content in a prevention strategy against scientific fraud (University Foundation). Brussels (Belgium), 10 June 2014.

Godecharle S., Nemery B., Dierickx K. (2014). Poster: Research Integrity and Misconduct: Diversity across Europe. Improving Scientific Practice: Dealing with the Human Factors. University of Amsterdam. Amsterdam (the Netherlands), 11 September 2014.

Godecharle S., Nemery B., Dierickx K. (2014). Guidance on research and publication ethics in Europe: are we talking past each other?. European Seminar 2014: European perspectives on publication ethics (Committee on Publication Ethics). Brussels (Belgium), 14 March 2014.

Godecharle S., Nemery B., Dierickx K. (2013). Research Integrity: No Harmony in Europe. 3rd World Conference on Research Integrity. Montreal (Canada), 5-8 May 2013.

Godecharle S., Nemery B., Dierickx K. (2013). Research Guidance in Europa. Kennismakers (Research Foundation - Flanders). Ghent (Belgium), 17 December 2013.

Godecharle S. (2013). Invited to chair focus group sessions. Good Practice in Research Ethics (UK Council for Graduate Education). University of York (United Kingdom), 23 May 2013.

Rawnsley A., Godecharle S. (2013). An Overview of Research Integrity Guidance. Good Practice in Research Ethics (UK Council for

Graduate Education). University of York (United Kingdom), 23 May 2013.

Meeting abstracts, presented at other scientific conferences and symposia, published or not published in proceedings or journals

Godecharle S. (2015). Cultuur van wetenschappelijke integriteit: een beleid op maat. Permanente vorming "Actuele Filosofie" 2015. Vakgroep Wijsbegeerte en Moraalwetenschap. Gent (UGent), 22 April 2015.

Godecharle S. (2014). Research integrity and misconduct from a European perspective: guidance and possible actions. Research fraud & integrity: what can and should be done?. Leuven (KU Leuven), 26 May 2014.

Meeting abstracts, presented at other professionally oriented conferences and symposia, published or not published in proceedings or journals

Godecharle S. (2015). Ethische en juridische aspecten van patiënten-informatie. Patiënten-informatie: waar ligt de balans tussen vertrouwen en schriftelijke *informed consent*?. General Hospital Turnhout (Belgium), 17 March 2015.

Godecharle S. (2013). Palliatieve sedatie: Ethische aspecten. Palliatieve sedatie is geen euthanasie. General Hospital Turnhout (Belgium), 13 November 2013.

University teaching experience

In the academic year of 2015-2016, I was part of the didactical team that provided research integrity training to doctoral students of the Doctoral School of Biomedical Sciences of the University of Leuven.

Participations at courses

I attended the European Regional Working Group of the Global Research Council (22 October 2012, Brussels: at the International Auditorium; parallel sessions concerning research integrity and open access publications).

I participated in the following symposium: "Moving beyond questionable research practices: Symposium on good research practice in the behavioral sciences" (the Royal Flemish Academy of Belgium for Science and the Arts, 05 February 2013).

I participated in the "NVivo10-training" organized by the Department of General Practice, University of Antwerp: 26/03/2013; Teacher: prof. D. Mortelmans.

I participated in the Online course "Introduction in quantitative research" organized by Boom Lemma uitgevers: 10/04/2013; Teacher: Nel Verhoeven.

I was selected to participate in the Doctoral Summer School of the League of European Research Universities (LERU) named: "Doing the right things right - Research Integrity in a Complex Society" (14-18 July 2014; Finland). Every university of the 21 members of LERU was allowed to select two candidates for this summer school.

I was selected to participate in the Doctoral Forum of the Fourth World Conference on Research Integrity (31 May - 3 June 2015, Brazil). This forum enables PhD students to interact with participants and discuss their research with leading international experts on research integrity and misconduct. Only eight applicants were accepted to participate in this doctoral forum.

Science popularisation

Godecharle S. (2014). De wetenschapper als koorddanser. *Tijdschrift voor Hoger Onderwijs en Management (TH&MA). Het geweten van universiteit en hogeschool, 21* (4), 10–14 (<http://www.thema-hogeronderwijs.org/assets/2014-04/2014-5-SimonGodecharle.pdf>).

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Personal contribution

All the retrieved guidance documents were thematically analysed by me, Simon Godecharle, provided they were available in English, French, German, Dutch or Italian. I performed the search for documents concerning research integrity or misconduct, collected, analysed and interpreted the data, wrote the first and successive drafts of the manuscript, figures, and tables. I conducted the interviews and tape recorded and transcribed the interviews. I read all the interviews several times, and coded the interviews. I also contacted the organizations involved with the empirical studies, performed the validation of the survey and the pilot study, conducted the studies and wrote the first and successive drafts of this PhD thesis.

Conflict of interest statement

I myself and the other authors of the research papers of this PhD thesis, have no conflict of interests.

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