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Factors influencing the promotion and implementation of research integrity in research performing and research funding organizations: A scoping review

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ABSTRACT

Promoting and implementing research integrity is considered the joint responsibility and effort of multiple stakeholders in the research community. We conducted a scoping review and analyzed 236 research articles and gray literature publications from biomedical sciences, social sciences, natural sciences (including engineering), and humanities that dealt with the factors that may positively or negatively impact the promotion and implementation of research integrity. Critical appraisal of evidence was performed for studies describing interventions aimed at research integrity promotion in order to provide insight into the effectiveness of these interventions. The results of this scoping review provide a comprehensive taxonomy of factors with positive or negative impact and their relatedness to individual researchers, research performing and funding organizations, and the system of science. Moreover, the results show that efforts for fostering and promoting research integrity should be implemented at all three levels (researcher, institution, system) simultaneously to deliver greater adherence and implementation of research integrity practices. Although various educational interventions aiming at research integrity promotion exist, we were not able to conclude on the effectiveness of explored interventions due to the methodological quality issues in the studies.

Introduction

Research integrity, defined as the ability to adhere to the highest professional standards in conducting research, is essential for upholding the reliability and trustworthiness in science (Steneck 2006). Together with research ethics, research integrity is a part of the responsible conduct of research (Steneck 2006). In addition to avoiding the infamous forms of research misconduct – fabrication, falsification, and plagiarism – research integrity comprises the awareness of other misbehaviors called detrimental research practices, such

as inappropriate authorship practices, lack of proper data management, or withholding of research findings (; Steneck 2006; Martinson, Anderson, and de Vries 2009; Bouter et al. 2016; NASEM 2017). Compared to falsification, fabrication, and plagiarism, detrimental research practices are less in the spotlight, occurring more often and jeopardizing the robustness and reliability of research (Bouter 2015; Buljan, Barać, and Marušić 2018). Studies showed that researchers' engagement in these practices is around 30% compared to fabrication, falsification, and plagiarism which is estimated to be around 2% (; Steneck 2006; Fanelli 2009; Martinson, Anderson, and de Vries 2009; Bouter 2015). Moreover, there is still no globally accepted list of what fits into detrimental research practices which leads to having different standards and approaches to these practices in institutional research integrity policies (Resnik, Rasmussen, and Kissling 2015; Resnik et al. 2015; Ravn and Sørensen 2021).

Promoting research integrity is considered to be the responsibility of multiple stakeholders. These stakeholders, including researchers, research organizations, funding organizations, and scientific publishers, must combine efforts to enable systemic changes on how research integrity standards are followed and implemented in the scientific environment. Each type of stakeholder has its set of responsibilities that contributes to the overall aim focused on the promotion and implementation of research integrity standards. Individual researchers have the responsibility to perform research following rigorous scientific standards outlined in the policies and other guidance documents. These standards or best practices permeate different research-related areas – research environment, training, mentoring and supervision, safeguards and ethical questions, data handling, collaboration, authorship, peer review, and research misconduct (ALLEA 2017; NASEM 2017). The policies and standards of research integrity are often developed and mandated by research organizations. Although this is an important contribution to the fostering of research integrity, research organizations have other responsibilities as well. These include raising awareness on research integrity, providing education and training, handling and sanctioning poor research behavior, and fostering an organizational culture of integrity through open communication, dialog, inclusiveness, support, and fair incentives system (Forsberg et al. 2018; Bouter 2020; Mejlgaard et al. 2020; Moher et al. 2020). At the same time, research funding organizations play a major role in shaping the behavior of both individual researchers and research organizations. Their contribution to research integrity is visible through the alignment of funding policies with requirements to research integrity standards (ICB 2010; Titus and Bosch 2010; NASEM 2017). Last but not least, scientific publishers and journals have the responsibility and are accountable for recognizing the mistakes in research and undertaking steps

that will ensure that only trustworthy and high-quality scientific knowledge is disseminated (Kleinert and Wager 2014; Christiansen and Flanagin 2017).

Despite the outlined stakeholders' responsibilities and efforts in promoting and fostering research integrity, the implementation of research integrity standards may not always be easy, without pitfalls, or even successful et all. This becomes evident as research misconduct and detrimental research practices still occur, which subsequently leads to greater consequences, such as slow progress of science, waste of resources, a decrease in the credibility of scientific work, and diminishment of public trust in scientific findings (Michalek et al. 2010; Fang, Steen, and Casadevall 2012; Bouter et al. 2016; Hussinger and Pellens 2017). Different factors may be positively or negatively associated as to why the implementation of research integrity standards may fail in practice. So far, research showed that at the level of individual researchers the implementation may be challenged due to internal factors (individual personality traits, lack of knowledge, negative or ignorant perception toward the importance of research integrity), or external, i.e., situational factors (financial issues, work issues, family or relationship issues) (Davis and Riske 2002; Mumford Michael, Conelly, and Leritz 2005; Tijdink et al. 2016a; Satalkar and Shaw 2019). At the organizational level, implementation of research integrity standards often depends on the organizational climate and the availability of processes and structures for both promoting research integrity and handling poor research behavior (Mumford and Helton 2002; Martinson et al. 2010; Amin et al. 2012; Olesen, Amin, and Mahadi 2017). Further, in the system of science there are still various rules related to career requirements that often facilitate a highly competitive or poor incentives system, and hinder the implementation of research integrity standards (Anderson et al. 2007a; Tijdink, Verbeke, and Smulders 2014; Bouter 2015; Maggio et al. 2019).

Although research aiming to obtain and systemize the knowledge on different factors that may have an impact on the implementation of research integrity standards has been conducted, it remains scattered across various literature and a comprehensive map of all potential factors does not exist. Moreover, the existing literature, although exploring various factors, usually identifies either the positive or negative impact of factors and does not take into account multiple disciplinary fields or multiple levels in which these factors can occur. To our knowledge, a comprehensive study that maps factors both positively and negatively related to research integrity promotion and implementation on different levels (individual researchers, organizational level, and the system of science), taking into account different stakeholders, geographic areas, and disciplinary fields, does not exist. This scoping review aimed to fill this gap by exploring the available knowledge on what facilitates or hinders the implementation of research integrity standards in practice, and provide a comprehensive map that can highlight the areas in

which more efforts are needed for optimal implementation of research integrity standards.

Methods

Considering the broadness of our study aim and the intention to map as many relevant publications, as well as identifying gaps in knowledge, we conducted a scoping review study (Davis, Drey, and Gould 2009; Rumrill, Fitzgerald, and Merchant 2010). We employed the methodology developed by the Joanna Briggs Institute (JBI) (Peters et al. 2015; Aromataris and Munn 2020). To report the study results, we followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist (Tricco et al. 2018). The study protocol was registered at the Open Science Framework (OSF) on April 11, 2019. The registration is a part of the WP3 (Systematic reviews of practices and research cultures) of the SOPs4RI project. The protocol is available at: https://osf.io/caefg/.

Eligibility criteria (study selection)

We included both peer-reviewed publications and gray literature related to factors that may positively or negatively impact the promotion and implementation of research integrity standards in research performing organizations and research funding organizations, and that are related to different levels of implementation – individual researchers, organizations, and the system of science. Further, we included studies related to different disciplinary fields – medical sciences (including biomedicine), natural sciences (including engineering), social sciences, humanities, and research in general (in cases when the study did not refer to any specific disciplinary field). Concerning journal publications, we did not have limitations regarding the type of publication, i.e., we included empirical research articles, commentaries, and editorials. However, commentaries and editorials were included in the final analysis only if they contained enough information about factors influencing research integrity (e.g., details about the effect of certain factors rather than just listing or referring to different factors without any details or explanations). For the empirical studies, we did not have limitations regarding study design as we wanted to include as many as possible articles relevant for our study aim. There were no language restrictions for the documents from the bibliographic databases; however, gray literature was restricted to English to limit the amount of documents to be retrieved in the search. Time limitation was set to 1990 as we considered that older publications would not provide an insight into the current state of affairs regarding different factors that impact research integrity promotion and implementation (Komić,

Marušić, and Marušić 2015). There were no geographical restrictions in the search. Since academic integrity often includes values and behavior relevant for researchers and research (Fishman 2014), we included publications related to academic integrity in our analysis only when these documents reflected on research and academic performance, and researchers' professional or unprofessional behavior.

Information sources and search

With the help of an information specialist from the University of Split School of Medicine, we developed a comprehensive search strategy. Since this study is a part of the larger project, we used the same search strategy as for the previous scoping review on another, related topic (et al. 2021). We searched Medline, Scopus, Web of Science (18 February 2019; updated 15 March 2021), and PsycINFO (12 February 2019; updated 16 March 2021). The search strategies are available in Appendix 1. We also searched the reference lists of the publications from the bibliographic databases which were included in the final analysis, in order to identify additional studies.

The gray literature search included several sources – web pages of the World Conferences on Research Integrity (WCRI), the Community Research and Development Information Service (CORDIS) database (Cordis.europa. eu), and publications of the National Academies of Sciences, Engineering, and Medicine (NASEM). Details of the gray literature search are available in Appendix 1.

Study selection

Articles from the bibliographic databases were exported into EndNoteTM (Clarivate Analytics, Philadelphia, PA, USA). We removed the duplicates and performed pilot screening on the sample of 100 documents to ensure that every researcher in the scoping review team understood the eligibility criteria correctly, and to avoid any misunderstandings in the further screening process. Three researchers (ARE, RR, and WK) performed the screening of titles and abstracts. RR screened titles and abstracts of all publications, and *ARE and WK* each screened half of the publications' titles and abstracts. The results were compared and discussed to decide on the publications eligible for the full-text screening. At least two reviewers had to agree on the inclusion of a document in the full-text screening. The full-text screening was performed by two researchers independently (IB and RR). The results were discussed, and in the cases of disagreements the third researcher (AM) was included for the final decision (agreement between the assessors, kappa = 0.91). One researcher (RR) performed the screening of the

references of the publications included in the final analysis. Screening of the gray literature was performed by one researcher (RR).

Data charting process

A data charting form was developed in advance, and data were extracted by one researcher (RR). This was done only after two researchers performed the full-text screening of all the articles independently and then discussed the articles for inclusion and data contained in articles. During this process, both researchers took notes and already extracted some data and information. The data extracted were: author(s); title; year of publication; reference type (for documents from bibliographic databases; e. g. journal article, book); country of origin; disciplinary field; relation to research performing organization, research funding organization, or both; identified factors (related to the individual researchers, organization, or the system of science); impact of factors (positive or negative). A short description of the intervention was described for interventional studies.

Critical appraisal of individual sources of evidence

The purpose of the critical appraisal of evidence was to assess the methodological quality of the studies and analyze whether appropriate steps were taken to reduce the risk of bias (Tufanaru et al. 2020). To assess the quality of studies describing interventions, we used JBI Critical Appraisal Tools. We used JBI critical appraisal checklists for quasi-experimental (non-randomized experimental studies), randomized controlled trials, and qualitative studies (Lockwood, Munn, and Porritt 2015; Tufanaru et al. 2020). All checklists provide questions to assess the methodological quality of studies. Four items (Yes; No; Unclear; Not applicable) are used as answers. AM and RR independently assessed the articles.

Data synthesis

Publications and extracted items were grouped by general characteristics (year of publication, type of publication, country of origin, disciplinary field, relatedness to the research performing organization or research funding organization or both). Based on the distinction between different levels and factors influencing research integrity promotion and implementation in the publications, we mapped them based on their relatedness to individual researchers, organizations, and system of science. We further categorized the identified factors based on their positive or negative impact on research integrity promotion and implementation and grouped the identified factors into topics to create an overview of research integrity-related areas addressed

in the publications. Additionally, for studies describing interventions, we summarized results based on the study design, intervention approach, sample size, outcome measure, and reported limitations.

Deviations from the study protocol

In the study protocol, we did not plan to perform methodological quality appraisal since it is not necessary to do so in the scoping reviews (Tricco et al. 2018). However, the methodological quality appraisal can be performed in the scoping reviews if the authors think that the analysis could have interesting or important findings that can provide implications for practice (Tricco et al. 2018). In our scoping review, the decision to perform the critical appraisal of evidence was brought during full-text screening since we noticed studies have different study designs; hence, those describing interventions could benefit our study aim by providing evidence on which factors related to different levels of implementation influence research integrity.

Results

Selection of sources of evidence

The search of bibliographic databases retrieved 32,887 publications; after removing duplicates, 26,805 publications were left for screening. After screening titles and abstracts, there were 386 publications for full-text screening. In the further step, 254 publications were excluded, and 132 were included in the final analysis and data extraction. The reference search of included articles yielded additional 43 publications for the final full-text analysis. The updated search of bibliographic databases retrieved 9,084 publications. After screening titles and abstracts, 83 publications were left for full-text screening, and in the next step, 40 publications were left for the final analysis (Figure 1). The search of gray literature sources retrieved 21 publications, so that the final number of analyzed publications was 236. The full list of included and excluded publications is available in the Online Supplementary Material.

Characteristics of sources of evidence

The largest number of publications included in the final analysis were journal articles (n = 203/236, 86%), followed by conference materials (n = 16/236, 6.8%), book sections (n = 8/236, 3.4%), books (n = 5/236, 2.1%), and reports (n = 4/236, 1.7%). Most publications were related or originated from the United States of America (n = 98/236, 41.5%), while 43 (n = 43/236, 18.2%)
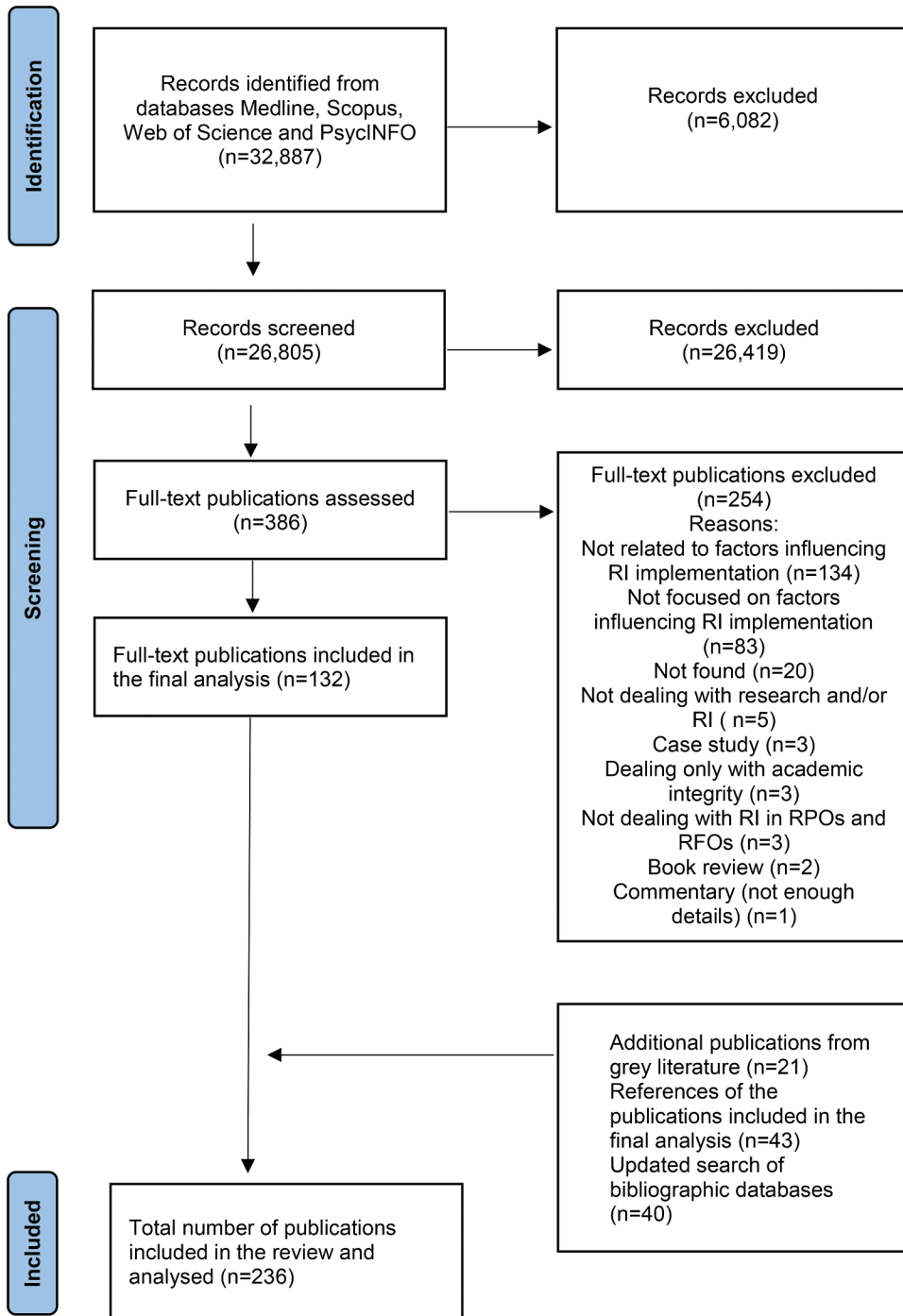
Figure 1. PRISMA flow diagram for the scoping review process.

publications were marked as "international" (publications that were not related to any specific country or countries but were more focused on research integrity on a global level or a certain geographic area, e.g., Europe). The majority of publications were related to medical sciences (n = 115/236, 48.7%) and research in general (n = 102/236, 43.2%). Also, the majority of publications were related to research performing organizations (n = 197/236, 83.5%). Regarding the publication period, our analysis included 16 publications dating from 1990 to 1999 (n = 16/236, 6.8%), 52 publications published from 2000 to 2009 (n = 52/236, 22%), and 150 publications from 2010 to 2019 (n = 150/236, 63.6%). In the period from 2020 to 2021, we identified 18 publications (n = 18/236, 7.6%).

Among the journal articles, the majority were reviews, perspectives, and opinions (n = 75/203, 36.9%). Concerning the methodological approaches of these studies, we identified 66 quantitative (n = 66/203, 32.5%), 35 qualitative (n = 35/203, 17.2%), and 9 mixed-methods (n = 9/203, 4.4%) studies; as well as 18 commentaries and editorials (n = 18/203, 8.9%). Almost all quantitative studies were surveys and questionnaires (n = 62/66, 93.9%), while a few studies were systematic reviews (n = 3/66, 4.5%) and meta analyses (n = 1/66, 1.5%). Regarding the qualitative studies, most of these studies were semi-structured interviews. As for the funding sources, journal articles (excluding commentaries and editorials) reported public (n = 72/185, 38.9%), public and nonprofit (n = 8/185, 4.3%), and nonprofit funding (n = 3/185, 1.6%). Moreover, 11 articles reported not receiving any specific funding for conducting the research (n = 11/185, 5.9%), while in almost a half there were no disclosures regarding funding sources (n = 91/185, 49.2%). The full list of publications, references, and characteristics are available in the Online Supplementary Material.

Factors identified in publications

In the following text, we present the factors that were most often mentioned across publications. Table 1 presents most often mentioned factors while the full taxonomy of all factors identified across publications is presented in Appendix 2.

Level: Individual researcher

At the level of the individual researcher, we defined three main topics in which we categorized publications addressing positive and negative factors (Table 1). Most of the analyzed publications mentioned factors that have a negative impact on research integrity promotion and implementation. The influence of supervisors and mentors is emphasized across many of the included publications. Supervisors and mentors have the ability to shape young researchers' behavior and this can go two ways. Either supervisors

Table 1. Taxonomy of the factors most often mentioned across publications included in the analysis.

	Positive	Negative
	Level: Individual researcher	
Environment and culture	• The role of mentors, supervisors, and senior researchers (role models – e.g., setting positive examples and modeling students' ethical behavior, having regular meetings with students, and providing guidance and help) • A culture of open communication, dialog, justice, and integrity	• The role of mentors, supervisors, and senior researchers (negative role models – e.g., not paying enough attention to young researchers' work, having pressure to supervise a large number of students, having a lack of appropriate training) • Precarious position of junior researchers (e.g., power imbalance between junior and senior researchers; junior researchers are afraid to discuss the research and its possible mistakes; junior researchers supporting senior researchers even when they are involved in poor research behavior) • Perverse incentives (e.g., incentives for publishing a lot of research; focus is on quantity rather than quality of research and on positive research results only) • Pressure (e.g., work-related stressors, competitive environment, academic performance metrics, overload of requirements) • Situational factors (e.g., financial and relationship issues) • Lack of protection for whistleblowers • Environment and culture differences (e.g., existence of various rules and differences between rules; different interpretation of guidance in different setting) • Lack of independence from industry (e.g., industry funds research, or training and education)
Personality traits, personal values, aspirations, and motivation	• Positive personality traits (e.g., high moral integrity, honesty, sense of social responsibility, respectfulness) • Willingness to report misconduct and other scientific dishonest behavior • Willingness to disclose conflict of interest	• Negative personality traits (e.g., vanity sloppiness, greed, Machiavellianism, etc.) • Wish for recognition, success, and financial gain (e.g., publishing extensively regardless of research integrity requirements, taking shortcuts, weighting consequences of research misconduct and rewards for scientific achievements) • Taking research integrity for granted (e.g., not agreeing with research integrity requirements and guidelines, perception of research integrity requirements as administrative burden) • Not declaring conflict of interest (related to career benefits and financial gain) • Not reporting misconduct (e.g., because of the fear of consequences)

(Continued)

Table 1. (Continued).

	Positive	Negative
Knowledge and skills	• Having research experience, good knowledge and understanding of research and research integrity • Completing research integrity or responsible conduct of research education (e.g., training for both junior and senior researchers; completing different types of educational courses tailored to the needs; completing training in research methodology; research integrity education for mentors and supervisors) • High awareness of the importance of research integrity and research integrity education, and knowledge of research integrity policies and procedures, good and poor research behavior, risks, and consequences of misconduct	• Lack of research integrity or responsible conduct of research education (or educational courses being too broad and general; lack of congruity from what is taught in educational courses and how it is in reality) • Lack of knowledge on research integrity, research integrity policies, and procedures • Not knowing or recognizing responsibilities (lack of experience)
Level: Research organizations		
Research environment and culture	• Fostering a culture of integrity, transparency, deliberation, compliance, collaboration, and inclusivity • Good ethical climate and organizational justice • Creating safe and trusty environment for discussing research integrity issues • Raising awareness on research integrity and research misconduct • Responding to misconduct cases • Promoting transparency (publishing incidence of research misconduct and other detrimental research practices)	• Poor organizational climate, governance, and leadership • Lack of positive organizational values • Focusing on profit and money, productivity and performance • Competitiveness between academic institutions • Lack of independence from industry (organizational conflict of interest) • Avoiding to investigate misconduct

(Continued)

Table 1. (Continued).

	Positive	Negative
Research integrity education and support	• Providing education on different research integrity issues and for different groups of researchers (junior and senior researchers, supervisors, administrators; tailoring research integrity education to different needs) • Implementing research integrity training into curriculum	• Lack of research integrity and responsible conduct of research training in the organization (or lack of effective education)
Research integrity policies, structures and processes	• Developing, implementing, and updating research integrity policies and guidance documents for different research integrity issues • Monitoring researchers' compliance with research integrity policies and guidance documents • Having adequate bodies to deal with research integrity and research misconduct issues (e.g., research integrity officers and committees, ombudsman, boards for conflict of interest, bodies for ethical research and publications, management system for research integrity questions) • Developing strategies to mitigate and resolve disputes (adopting formal policies and implementing processes for addressing allegations and conducting investigations of research misconduct) • Implementing sanctions for research misconduct • Developing a program for the whistleblowers' protection • Developing a comprehensive plan to promote research integrity	• Lack of research integrity policies and guidance documents • Lack of clear, detailed and uniformed research integrity policies and guidance documents • Lack of proper oversight • Lack of effective system for dealing with allegations and misconduct cases • Lack of sanctions for research misconduct

(Continued)

Table 1. (Continued).

	Positive	Negative
Evaluations, incentives, and rewards	• Putting focus on quality of research and scientific process instead of prestige, ranking and financial gain • Evaluating and awarding research based on research integrity requirements	• Performance-based evaluations (e.g., performance-related salaries and perverse incentives; valuing quantity of research instead the quality)
Research integrity in funding organizations	• Developing and implementing policies and procedures for research integrity promotion and investigation of research misconduct • Funding and evaluation criteria (putting more emphasis on research integrity)	• Evaluations based on research topic attractiveness rather than on quality of research (output-oriented funding)
Level: System of science		
Global research culture	• Research metrics (valuing quality over quantity) • Reducing over-competitiveness • Establishing a common system for dealing with research integrity and research misconduct (having national, independent bodies for research integrity training and misconduct investigations)	• Pressure to publish (publish or perish; research community puts too much emphasis on the number of publications and creates pressure – the number of publications is taken into account for career advancement, tenure track, research awards, obtaining funding, etc.) • Focus on competition and productivity (incentive system based on number of publications and productivity; institutional ranking based on productivity) • Differences between countries and disciplinary fields in defining poor research behavior (e.g., lack of harmonization on research integrity concepts, policies, and procedures; in some countries cheating is more acceptable or different level of emphasis is given to different research integrity issues)
Scientific journals and publishers	• Having clear policies and procedures for research integrity issues • Implementing practices for research misconduct (e.g., retracting fraudulent publications, informing research organizations about suspected misconduct, cooperating with research organizations in investigations)	• Lack of enthusiasm to publish negative research results

and mentors are role models that respect research integrity standards in their work and spend enough time with supervisees to guide them on responsible research practices (which is seen as a factor that positively impacts research integrity promotion); or they act as negative role models because they are unskilled or perhaps overworked in their job and supervising responsibilities, or uninvested in research integrity (Anderson et al. 2007b; Kalichman 2007; Mumford et al. 2007; Roland 2007; Gray and Jordan 2012; Olesen, Amin, and Mahadi 2018a; Olesen et al. 2020; Li and Cornelis 2021). Some publications explored the role of researchers' personalities on research behavior. They found that different personality traits are often related to how researchers think, feel, behave, and cope with pressuring academic environment. For example, having negative personality traits like narcissism, cynicism, egoism, self-entitlement, or negligence might be related to researchers not following the research integrity policies and standards in their work (Antes et al. 2007; Davis and Diaz 2007; Amin et al. 2012; Tijdink et al. 2016a). On the other hand, having high moral values such as honesty, respect toward others, and awareness of social responsibility is often related to paying more attention to research integrity and adhering to the existing rules (Kalichman 2007; Macfarlane and Saitoh 2008). Often, negative personality traits are related to different desires such as: the desire for recognition, success, fame, or financial gain (Satalkar and Shaw 2019; Abbasi et al. 2020), which may also mean that researchers scoring high on specific negative personality traits could break the rules to achieve their goals. There are also external factors that influence researchers' behavior. The publish or perish mantra and influence of commercialized research, perverse incentives, the pressure to publish in high impact factor journals, as well as pressure to obtain funding and tenure were often mentioned across publications as negative factors (Fanelli, Costas, and Larivière 2015; Buljan, Barać, and Marušić 2018; Godecharle, Nemery, and Dierickx 2018; Olesen, Amin, and Mahadi 2018a, 2018b). Changing research metrics requirements, evaluation, and award structures by emphasizing research integrity and quality of research instead of quantity are seen as solution to ease the pressures (Bruton et al. 2020; Haven et al. 2020; Abdi et al. 2021). Another external factor that influences researchers' adherence to research integrity is the willingness to report research misconduct and other detrimental research practices. Often, breaches of research integrity go unsanctioned which may encourage others to partake in poor research behavior and at the same time discourage those who pursue their academic career with integrity to report the breaches to the institutional bodies (Martinson, Anderson, and de Vries 2009; Redman and Merz 2005; Buljan, Barać, and Marušić 2018). In some cases, researchers are not willing to report misconduct because they do not trust the system and are afraid of negative consequences for their work as adequate support for whistleblowers is lacking (Rhodes and Strain 2004; Redman and Merz

2005; Allen and Dowell 2013; Bruton et al. 2020; Olesen et al. 2020). Researchers' willingness to actively pursue research integrity standards in practice was also often mentioned in the context of conflict of interest. According to the publications, researchers do not disclose the conflicts of interest mainly because the conflict benefits them (as we previously mentioned due to the commercialization of research and opportunities for financial gain), or they lack the awareness of what constitutes conflict of interest, as well as why and how to disclose it (DeCensi et al. 2018; Godecharle, Nemery, and Dierickx 2018). Disclosure of conflict of interest was nevertheless mentioned in the context of factors that promote and foster research integrity standards (Lipton, Boyd, and Bero 2004; Bion et al. 2018; DeCensi et al. 2018). Most publications at the level of the individual researcher were included in the topic related to researchers' knowledge and skills. Research and research integrity experience, often obtained through research integrity education, are seen as factors that facilitate the promotion and implementation of research integrity standards. Completing some form of research integrity education and training was seen as a positive factor or at least the first step in encouraging researchers to apply research integrity standards in their work. Research integrity education is considered to benefit the researchers by enabling them to develop a greater knowledge and awareness of research integrity and research misconduct, knowledge of how to act in challenging research integrity situations, and the importance of research integrity for the science (Olesen et al. 2019; Satalkar and Shaw 2019; Hofmann et al. 2020; Abdi et al. 2021). On the other hand, the lack of research integrity education and training are seen as factors that hinder the promotion and implementation of research integrity. However, it is important to bear in mind that not all of the studies explored whether certain interventions on research integrity education are effective. Some studies that did explore the effectiveness are included in our critical appraisal analysis and presented in the section *Interventions aiming at research integrity promotion and implementation*.

Level: Research organizations

At the organizational level, we categorized publications addressing positive and negative factors related to five main topics (Table 1). In the topic related to the research environment, publications most often referred to the organizational climate which can be ethical or unethical; and developed to promote research integrity or to sweep issues under the carpet. The latter was seen as a major issue that hinders the implementation of research integrity not only at the organizational level but also at the level of the individual researcher as policies and practices established in the organizations shape the behavior and attitudes of researchers (Olesen, Amin, and Mahadi 2017; Zwart and Ter Meulen 2019; Haven et al. 2020). When an organization focuses and invests

on developing a culture of integrity, transparency, collaboration, and inclusivity in which research integrity is valued and promoted, while cases of research misconduct are properly handled; these steps can contribute to developing a culture that will positively influence researchers' behavior (DuBois and Antes 2018; Zwart and Ter Meulen 2019; Haven et al. 2020). On the contrary, when an organization is too invested in competitiveness and rankings at the cost of denying, ignoring, or even covering up research misconduct to preserve their reputation, an unhealthy research environment is created, in which researchers may be prone to avoid rules and good practices (Breit and Forsberg 2016; Haven et al. 2019a; Olesen et al. 2020). As mentioned in the topic related to the research integrity policies and structures, one way of contributing to the development of a good organizational culture, which is often mentioned across publications as a positive factor, is having in place codes of conduct, guidelines, and other research integrity guidance documents, as well as comprehensive research integrity plans for its promotion. Another positive factor is the establishment of administrative bodies, as well as procedures, for handling research misconduct cases. However, it is important not only to establish these bodies but to ensure that those who work within these bodies receive adequate training and that there are clear guidelines on how to approach misconduct cases and how to handle investigations (Korgan Hausbeck Kathryn 2016; Bramstedt 2021). The topic related to research integrity education included publications that referred to the responsibility of organizations to establish and organize research integrity educational courses and trainings for researchers. A comprehensive effort in this area would be implementing research integrity training into the curriculum (Vasconcelos et al. 2015; Yi, Nemery, and Dierickx 2019). Further, at the organizational level, some of the included articles focused on research funding organizations where several issues were outlined as factors that negatively influence research integrity promotion and implementation. These include, for example, "output-oriented funding" in which funders provide grants based on solely the research topic attractiveness rather than on the quality of the proposed research (Martinson et al. 2009; Tijdink et al. 2016b). Given that research grants can have a huge impact on researchers' careers and the visibility of research results, funders must employ proper measures that will ensure the greater applicability of research integrity standards when providing research funds (Bloch et al. 2014; Bouter 2015). According to the publications included in the review, these may include funders developing and implementing research integrity and research misconduct policies and putting more emphasis on research integrity when it comes to evaluating research proposals (Mahmud and Bretag 2014; Evans et al. 2018; van Wee 2019).

Level: System of science

At the level of the system of science, we categorized publications based on positive and negative factors related to two main topics – global research culture and scientific journals and publishers (Table 1). The majority of publications addressed factors that have a negative impact on research integrity. Many publications focused on the pressures and trends in academia and efforts to make changes in how research is evaluated. Currently, the research system is pervaded with a focus on high competition, productivity, and quantity of research publications instead of quality. Publications included in the review propose a change in how scholarly work is evaluated as a possible solution, as well as being a factor that may positively influence research integrity promotion and implementation. Overreliance on a single metric when judging the impact of scholarly work should be replaced by introducing more qualitative metrics, as well as introducing metrics related to research integrity (Edwards and Roy 2017; Yi, Nemery, and Dierickx 2019). For example, assessing the methodological quality of publications or evaluating researchers' adherence to open science initiatives, such as publishing in open access or sharing research data. Differences between countries and disciplinary fields in defining poor research behavior and misconduct were mentioned as prominent issues that hinder the promotion and implementation of research integrity (Resnik, Rasmussen, and Kissling 2015; Godecharle, Nemery, and Dierickx 2018; Liao et al. 2018; Shaw 2019). The issues are further complicated when it comes to questionable or detrimental research practices as there is often a considerable difference in definitions among disciplinary fields and countries, making it harder for researchers to discern proper and responsible research behavior (Bouter et al. 2016; Ravn and Sørensen 2021). In that sense, some articles included in our review highlighted the need for harmonizing research integrity policies by adopting common definitions and frameworks of basic research integrity concepts, as well establishing common procedures for dealing with research integrity issues (Olesen, Amin, and Mahadi 2019; Wang and Li 2020). Further, at the level of the system of science, initiatives from scientific journals and publishers were mentioned as important for fostering research integrity. Some of these include publishing research with negative results, providing more guidance for reviewers, and employing preregistration and data sharing practices. Moreover, journals should collaborate with research organizations in promoting research integrity by informing one another about suspected misconduct, and cooperating in investigations (Wager and Kleinert 2012). Among the factors with a negative impact, publications mostly referred to the journals publishing only positive research results, lack of clear policies addressing research misconduct, neglectful or irresponsible publication practices by peer reviewers and editors.

Interventions aiming at research integrity promotion and implementation

Overview and characteristics of studies

We identified 10 studies describing interventions for research integrity, research ethics, and responsible conduct of research. Studies were published from 2008 to 2020 and were pre-and-posttest studies (n = 5) (Kligyte et al. 2008; Antes et al. 2010; Jordan and Gray 2012; Gray and Jordan 2012; Mabou Tagne et al. 2020), randomized controlled trials (n = 2) (Martinson et al. 2017; Bruton et al. 2020), pre-and-posttest with posttest only (n = 1) (Powell, Allison, and Kalichman 2007), pre-and-posttest with follow up (n = 1) (Mumford et al. 2008), and qualitative research (n = 1) (Seiler et al. 2011). The studies varied in population type and sample size. Most often the population included graduate and postgraduate students from natural, social, and biomedical sciences. The number of participants ranged from 24 to 1002. The interventions also varied. Most of the studies had face-to-face interventions related to different approaches to responsible conduct of research and ethics training and education such as short-term training, sensemaking training, and role-play scenarios. Most often reported studies' limitations were limited sample size and lack of the control over test-taking environment. The main findings from the studies showed that research integrity education is important for researchers' knowledge and awareness of good and poor research practices (Mabou Tagne et al. 2020) and might increase the level of trust among researchers (Jordan and Gray 2012). Sensemaking or role-play approach to research integrity and responsible conduct of research education might positively influence researchers' ethical decision process (Kligyte et al. 2008; Mumford et al. 2008; Seiler et al. 2011), as well as mentors and supervisors that play an important role in shaping students' attitudes toward academic integrity (Gray and Jordan 2012). On the other hand, some studies showed that responsible conduct of research education could have a harmful effect by encouraging researchers to feel overstressed or have overconfidence in their research integrity knowledge (Antes et al. 2010); another warning was that short-term education does not provide long-term effects and should be substituted with more concrete or periodical education (Powell, Allison, and Kalichman 2007). Moreover, studies reported that having direct communication with research leaders and reporting to them their thoughts of the existing organizational climate seems to contribute to positive changes and improve the organizational ethical environment (Martinson et al. 2017), as well as that institutional incentives play a major role incentivizing questionable or detrimental research behavior (Bruton et al. 2020). An overview of the studies describing interventions and its characteristics are available in Table 2.

Table 2. Overview of characteristics of studies describing interventions for research integrity promotion.

Source	Study design	Study population and setting	Sample size	Interventions and delivery mode	Outcome measures	Key findings	Reported limitations
Powell, Allison, and Kalichman 2007	Pre-and-posttest and posttest only	Medical students participating in Summer Research Program which includes responsible conduct of research course.	65 (15 pretest, 50 posttest)	Short-term responsible conduct of research training; face to face	Research ethics survey for assessing the effectiveness of a short responsible conduct of research course	Short-term responsible conduct of research education has little or no influence on improving the skills and behavior of researchers	Lack of control over test-taking environment and possible influence of other external factors on outcomes
Kligyte et al. 2008	Pre-and-posttest	Members of the large, multi-cultural, multi-disciplinary, and multi-university research center working on developing remote sensing technology for weather studies	42 (34 male, 8 female)	Sensemaking training; face to face	Ethical-decision making measure (12 scenarios addressing different disciplinary fields mapped according to 4 main domains – data management, study conduct, professional practices, and business practices)	The sensemaking responsible conduct of research training had a positive effect on researchers' ethical decision-making in data management, study conduct, professional practices, and business practices	Limited sample size (including limited sample size in pre-and-post comparison); training conducted in single research center; not clear whether sensemaking training would have an effect on other research integrity measures; follow-up was not conducted for long-term effects
Mumford et al. 2008	Pre-and-posttest design with follow up	Doctoral students working in the biological and social sciences; control group – doctoral students from the biological, health, and social sciences	59 (19 men, 24 women, 16 unreported); 245 participants in the control group (95 men, 144 women, 6 unreported)	Sensemaking training; face to face	Ethical-decision making measure	The sensemaking responsible conduct of research training led to improvements in ethical decision-making, and improvements were maintained over time	Lack of control over test-taking environment and possible influence of other external factors on outcomes; study conducted at single university and in two disciplinary fields; voluntary nature of participation

(*Continued*)

Table 2. (Continued).

Source	Study design	Study population and setting	Sample size	Interventions and delivery mode	Outcome measures	Key findings	Reported limitations
Antes et al. 2010	Pre-and-posttest	Participants in the responsible conduct of research course at US universities (students of biological, health, and social sciences)	173 (men 35%, women 58%, unreported 7%)	Responsible conduct of research educational courses; online	Ethical-decision making measure	Responsible conduct of research education may not be effective enough and can even be harmful in some cases (e.g., leading to overstress, overconfidence and overemphasizing ethical nature)	Lack of control over test-taking environment and possible influence of other external factors; limited sample size for pre-post comparison; only one outcome measure
Seiler et al. 2011	Qualitative study	Graduate science and engineering students.	41 (17 attended role-play session, 13 attended a case discussion session, 11 untrained); 23 men, 18 women	Role-play scenarios and "think aloud" case analysis; face to face	Analysis of interviews to assess the effectiveness of role-playing and case discussion approaches to responsible conduct of research education	Role-play approach to responsible conduct of research education may promote deeper appreciation of responsible conduct of research	Questions were broad; small sample size and age difference between participants; conducted in a single institution
Jordan and Gray 2012	Pre-and-posttest	MPhil. and PhD students participating in courses on research ethics at the University of Hong Kong	1002 participants (549 pretest and 453 posttest)	Responsible conduct of research education; face to face	30-question survey with a Likert scale for assessing increase or decrease of the level of trust between researchers after completing responsible conduct of research education	Responsible conduct of research training may be related to students having less trust toward their supervisors and senior researchers and more trust and stronger belief in the ethical behavior of peers	Relatively small population at single institution, English language proficiency, collusion on survey responses

(Continued)

Table 2. (Continued).

Source	Study design	Study population and setting	Sample size	Interventions and delivery mode	Outcome measures	Key findings	Reported limitations
Gray and Jordan 2012	Pre-and-posttest	MPhil. and PhD students participating in courses on research ethics at the University of Hong Kong	1002 participants (549 pretest and 453 posttest)	Research ethics courses; face to face	30-question survey with a Likert scale for assessing the relationship between researchers and supervisors after responsible conduct of research education	Supervisors play an important role in shaping students' attitudes toward academic integrity; some supervisors may feel burden of mentorship	Not reported
Martinson et al. 2017.	Randomized controlled trial	Research Service leaders from the Veterans Health Administration (VA) facilities	24 (21 completed follow up)	Phone-based and e-mail based report on survey results on organizational climate; online and telephone conversation	Survey of Organizational Research Climate (SOuRCe) consisted of 32 items for assessing the effectiveness of reporting the results of the survey on organizational climate to research leaders	Survey-based feedback on organizational culture does not have enough potential to incentivize positive changes in organizations, while having telephone conversations with leaders and written feedback may incentivize some positive changes contributing to better research integrity culture within the organization	Pilot project; conducted during media coverage and controversy related to Veterans Health Administration (possible impact on institutional leaders' willingness to participate in the study)
Bruton et al. 2020	Randomized controlled trial	Principal Investigators funded by the US National Institutes of Health and National Science Foundation	287 (123 men, 115 women, 4 unreported)	Short statements about research ethics; online	Narrative responses on different statements about, for example, research ethics, research misconduct, and questionable research practices; the study also used a Likert scale in combination with open-ended questions	Institutional and career-oriented incentives may encourage the use of questionable research practices; there is a lack of confidence in the effectiveness of ethics training in improving research behavior	Extensive input from participants was not collected through reaction question hence useful feedback was perhaps missed; study design did not well-structured to bring disciplinary differences in spotlight

(Continued)

Table 2. (Continued).

Source	Study design	Study population and setting	Sample size	Interventions and delivery mode	Outcome measures	Key findings	Reported limitations
Mabou Tagne et al. 2020	Pre-and-posttest	Researchers from University of Insubria, Italy (students, PhD students, clinicians, lecturers, researchers, and post-docs	65 (28 men, 37 women)	One-week intensive course on methodology, ethics and integrity; face to face	Closed-ended questionnaire based on the Scientific Misconduct Questionnaire (SMQ-R)	Research integrity training is considered important for good research and research evaluations should change by putting emphasis on qualitative rather than bibliometric criteria	Limited sample size; sample not representative; possible risk of misinterpreting questions by participants

Critical appraisal of sources of evidence

For the assessment of the methodological quality of evidence we used a JBI Critical Appraisal Tool checklist for quasi-experimental studies, consisting of nine items, for analyzing the studies with the pre-and-posttest study design, pre-and posttest with the posttest only, and pre-and-posttest with the follow up (Powell, Allison, and Kalichman 2007; Kligyte et al. 2008; Mumford et al. 2008; Antes et al. 2010; Gray and Jordan 2012; Jordan and Gray 2012; Mabou Tagne et al. 2020). We added supplementary criterion (who created the intervention, who delivered it and who analyzed the data) to assess the risk of bias for researchers who conducted the studies. For the randomized controlled trials (Martinson et al. 2017; Bruton et al. 2020) we used the checklist which consists of 13 items, while for the qualitative study included in this analysis (Seiler et al. 2011) we used a checklist for assessing qualitative studies that contains 10 different items.

All included studies had issues related to the methodological quality in at least one category of the Critical Appraisal Tool checklist, which further implies that the methodological quality could be improved and that the effectiveness of the tested research integrity interventions cannot be definitely asserted. For example, all quasi-experimental studies included in the analysis adequately reported and stated the study aim, intervention, outcome of interest and the connection between these (Powell, Allison, and Kalichman 2007; Kligyte et al. 2008; Mumford et al. 2008; Antes et al. 2010; Gray and Jordan 2012; Jordan and Gray 2012; Mabou Tagne et al. 2020), and in most studies outcomes were measured in a reliable way (Powell, Allison, and Kalichman 2007; Kligyte et al. 2008; Mumford et al. 2008; Antes et al. 2010; Mabou Tagne et al. 2020), and appropriate statistical tests were employed for data analysis (Powell, Allison, and Kalichman 2007; Mumford et al. 2008; Gray and Jordan 2012; Jordan and Gray 2012; Mabou Tagne et al. 2020). However, in all studies, the posttest or follow up was not completed and in several studies the differences and characteristics of participants included in pre-and-posttests were not adequately presented and the analysis of loss was not performed (Mumford et al. 2008; Gray and Jordan 2012; Jordan and Gray 2012; Mabou Tagne et al. 2020). Further, some studies did not adequately report the statistical analysis so it was unclear whether appropriate tests were used (Kligyte et al. 2008; Antes et al. 2010). The two randomized controlled trials included in the analysis, according to the Critical Appraisal Tool checklist, had a high methodological quality in categories related to properly conducting randomization and employing the appropriate statistical tests (Martinson et al. 2017; Bruton et al. 2020). However, in both randomized controlled trials we could not conclude on the methodological quality in categories related to the allocation of intervention and participants' bias as it was not clear and stated whether the allocation was concealed and whether participants were

blinded, both important factors for minimizing the risk that may bias the research results. Moreover, in Bruton et al. (2020) it was also not clear whether the research assessors were blinded and in both studies it was not stated whether participants were similar at the baseline (Martinson et al. 2017; Bruton et al. 2020). In the qualitative study by Seiler et al. (2011) almost all categories from the Critical Appraisal Tool checklist were adequately reported, indicating a high methodological quality. Only one item was not reported, related to addressing the potential influence of researcher on research and vice-versa. The details of the analysis are presented in Appendix 3.

Discussion

The analysis of publications included in this study identified various factors that may positively or negatively impact research integrity promotion and implementation. Most of the documents were related to biomedical sciences or research integrity in general (not related to specific disciplinary field) and addressed different factors, at all three levels – individual researchers, organizational, and the science system. Although many publications addressed elements that can encourage adherence to research integrity, most of them were focused on factors with a negative impact, i.e., factors that may hinder research integrity promotion and implementation, and encourage research misconduct and other poor research practices. The analysis of research integrity interventions showed that some formats of responsible research education may be more beneficial than others in promoting and implementing research integrity. However, this scoping review showed that there are difficulties in assessing the effectiveness of these interventions due to the methodological quality issues identified in the studies. In this section, we refer to the areas that were often mentioned across publications in the context of what hinders research integrity implementation, as well as efforts and improvements needed to identify changes that can be applied and have a positive impact on strengthening research integrity.

Studies that assessed research integrity interventions showed that research integrity education is an important aspect of promoting and implementing research integrity among researchers. However, based on the studies' findings, the available education might be suboptimal in delivering the full benefits of research integrity training, and studies suggested modifications in the content and delivery of training. Based on the findings, several recommendations and implications for practice can be made. First, novel approaches to research integrity education, such as sensemaking or role-play scenarios seem to engage researchers more and hence provide a better solution for education, compared to ordinary theoretical lessons. Research integrity education initiatives should then consider more interactive, active, and

engaging activities that include the development of role-play scenarios, cases, and metacognitive reasoning strategies. Recent research shows that although many research integrity educational resources and trainings are available, they still mostly imply passive rather than pro(active) participation by users (Pizzolato, Abdi, and Dierickx 2020). Second, studies suggested the training should take into account that one size does not fit all. Future training initiatives should strive to be tailored to the needs of trainees, considering their disciplinary field or research methods needs, which could affect positively researchers' perceptions of training and help in internalizing the knowledge. A similar was also explicitly proposed by researchers in other studies (Labib et al. 2021; Pizzolato and Dierickx 2021; Roje et al. 2021) which shows that tailoring education is urgently required. Moreover, a virtue-based approach to research integrity education was explored as a way of achieving the internalization of research integrity standards. Emphasizing the character, virtues, and values of the individual researchers may contribute to greater adherence to research integrity standards (Tomić, Buljan, and Marušić 2021). The third recommendation is related to studies proposing that short-term education is non-effective enough in ensuring the long-term effects of training. Hence, research integrity education that would be held over a certain period or at different points of the researcher's career could be a better solution for ensuring the full effects of the training. Considering the results of our critical appraisal of evidence that showed the existence of methodological issues in studies that tested research integrity interventions, we cannot completely conclude on the effectiveness of the proposed research integrity education initiatives, future research, for example, a systematic review that would assess the effectiveness of all available research integrity education programs could further contribute to the development of an optimal research integrity education program that will deliver the most success.

The studies in our scoping review often mentioned the importance of having in place codes of conduct, guidelines, and other guidance documents and policies for research integrity promotion, which is also in accordance with other newer studies (Mejlgaard et al. 2020; Ščepanović et al. 2021; Roje et al. 2021). However, the studies in our scoping review also emphasized that the mere existence of these policies does not necessarily mean that the policies are effective in improving the adherence to research integrity and reducing research misconduct and detrimental research practices. The lack of effectiveness is often related to pitfalls in the policies' implementation process. For example, Mabou Tagne et al. (2020) explored researchers' knowledge and perceptions of the institutional rules and procedures for reducing research misconduct and found that researchers perceived the policies as highly effective; however, they emphasized that the possibilities of actually being caught and sanctioned for research misconduct are very low. This may

indicate that the implementation processes of research integrity and misconduct policies are suboptimal. Moreover, some studies emphasized the lack of researchers' awareness of the existing research integrity and misconduct policies which may indicate that the proper implementation, awareness-raising, and educational activities were not conducted (Nilstun, Löfmark, and Lundqvist 2010; Azakir et al. 2020). Several other studies included in our analysis dealt with the content of research integrity and misconduct policies showed inconsistencies in definitions, and described courses of action in policies, as well as the lack of support and guidance on how to act when dealing with various research integrity issues. These inconsistencies and lack of support contribute to the lack of understanding of the policies, susceptibility to multiple interpretations, and misinterpretation of policies by researchers in practice (Cho et al. 2000; Lipton, Boyd, and Bero 2004; Mahmud and Bretag 2014; Fanelli, Costas, and Larivière 2015; Aubert Bonn, Godecharle, and Dierickx 2017; Olesen et al. 2020). To achieve better implementation of research integrity policies, research organizations, and other policymakers should consider developing the policies together with and not only for researchers (Roje et al. 2021). This could perhaps include involving researchers in the development process and fostering open discussions on the needs and requirements from different disciplinary fields and academic systems in order to include this in the policies.

The implementation of policies may not be the only issue as the mere existence of research integrity policies and a great diversity between the content of policies and issues on which focus is put is still a characteristic of certain disciplines or research areas. While other scoping reviews showed the lack of research integrity guidance documents and policies in some disciplinary fields, such as natural sciences and humanities (Ščepanović et al. 2021), the analysis of studies included in our scoping review also yielded a small number of studies referring explicitly to natural sciences and humanities and showed how different research integrity topics and issues are addressed and emphasized across different disciplinary fields. While issues related to conflicts of interest, collaboration with industry, and independence in industry-funded research are often mentioned across studies in medical sciences, these topics are not so common in other disciplinary fields. In our scoping review, studies from natural sciences and social sciences and humanities mostly addressed issues related to evaluation criteria, pressure to publish, plagiarism issues, and lack of sanctions for research misconduct. Other studies also reported differences in prioritizing research integrity topics across different disciplinary fields. A study by Haven et al. (2019b) showed that researchers from biomedical sciences and social science prioritize sloppy science and supervision issues, compared to researchers from natural sciences and humanities that emphasize issues related to the plagiarism and stealing of ideas before publication. Another study by Haven et al.

(2019c) showed that researchers from natural sciences have an overall more positive perception of research integrity compared to their colleagues from social sciences and humanities that are often dealing with for example plagiarism issues. Moreover, this research showed that in social sciences and humanities there is a lack of emphasis on regulatory bodies, which often do not even exist, while in biomedicine different regulatory bodies and committees exist for a long time and play a big role in evaluating and approving research. This points to the fact that not all research integrity topics are equally important across disciplinary fields, and when creating research integrity policies, the priority should be given to topics that are considered as most important to researchers from certain disciplinary field. However, within a disciplinary field, the same priorities should be given and efforts should be made in order to harmonize the policies and standards that researchers should follow.

Besides the problems of the lack of policies for research integrity, another factor that may hinder the implementation of research integrity standards is related to the existence of structures for dealing with research integrity issues and breaches. Adequate procedures, processes, and specialized research integrity bodies for sanctioning poor research behavior and protecting the parties involved in misconduct investigations still do not exist in many research organizations. Moreover, in many research organizations, there is no clear distinguishment between research ethics and research integrity which are by now known to be two connected, often overlapped, but different concepts (Steneck 2006; Pupovac, Prijić-Samaržija, and Petrovečki 2017; Marušić 2019). While research ethics is a more generic concept, focused on addressing the application of ethical principles and values to research; research integrity is centered around adherence to professional standards and responsibilities set up by research organizations and the research community (Steneck 2006; Marušić 2019; Hermerén et al. 2019). This distinction imposes distinct questions and issues that should be handled by different organizational bodies – research ethics bodies for ethical issues in research (most often related to conducting research with animals and human participants), and research integrity bodies for issues related to good research practice and professional standards (e.g., good authorship and publication practices, data management, peer review, etc.). Articles included in our analysis emphasized the importance of establishing research integrity procedures and processes, as well as specialized research integrity bodies that will deal explicitly with research integrity issues, as crucial for research integrity promotion (Fanelli, Costas, and Larivière 2015; Bramstedt 2021). How to effectively establish these bodies and what resources should organizations invest in them are the main questions to be addressed. Organizations can learn from one another through collaboration and follow best practices and examples. Another possibility is for organizations to

develop a research integrity promotion plan that will help it assess its needs, available resources, and develop research integrity practices accordingly (Mejlgaard et al. 2020).

Many articles included in the review referred to negative factors such as "publish or perish" and other pressures, as well as commercialization of research (Krimsky 2003; Godecharle, Nemery, and Dierickx 2018). Although some argue that pressure to publish has less influence on misconduct compared to inadequate misconduct policies, norms valued in research culture, and career stage (Fanelli, Costas, and Larivière 2015), others showed that researchers still perceive different career pressures as one of the main reasons for breaching the rules (Haven et al. 2019a; Bruton et al. 2020; Roje et al. 2021). Moreover, it is interesting that articles addressing these factors date from the 90s (Hilgartner 1990; Jasanoff 1993), and the same issues are present today (Hoole 2019; Aprile, Ellem, and Lole 2020; Harvey 2020; Holtfreter et al. 2020), which seems to indicate that the scientific community still has no solution on how to avoid pressure-related misconduct. However, the last decade has seen many initiatives to change the pressure-pervaded system of science. Documents such as the Declaration on Research Assessment (DORA (Declaration on Research Assessment) 2012), the Leiden Manifesto (Hicks et al. 2015), and the Hong Kong Principles for assessing researchers (Moher et al. 2020) propose steps that research organizations and the scientific community can take to minimize and avoid these pressures. Some organizations have already implemented these changes. For example, Ghent University and Utrecht University have abandoned researchers' evaluations based on the impact factor of published articles (Ghent University 2021; Woolston 2021), focusing instead on the career development of researchers.

Collaborations established between universities and industry to conduct research were often mentioned across publications included in our scoping review. According to the literature, the intense and frequent research collaborations between universities and industry made plenty of research applicable in practice and contributed to the progress of science and the wellbeing of society (Krimsky 2003). On the other hand, these collaborations presented extensive and unforeseen issues for researchers and research organizations (financial and other types of conflicts of interest, lack of independence from industry and biased research publications, and commercialization of research or doing research purely for financial gain and success); which are seen as factors that can endanger research integrity principles and diminish the promotion and implementation of research integrity policies and practices (Emanuel and Steiner 1995; Cho et al. 2000; Krimsky 2003; Liang and Mackey 2010). Research has shown that universities and industry often have differing visions on what research integrity or research misconduct is; however, today, thanks to the continuously developing field of research

integrity, we know that some practices could help align these visions and help both universities and industry to ensure objectivity and trustworthiness of research publications (Godecharle, Nemery, and Dierickx 2018). Research integrity education, which covers the different types of conflicts of interest and the importance of declaring these conflicts openly, is of paramount importance, as well as the organizations' responsibilities in developing and properly implementing conflict of interest policies (Lipton, Boyd, and Bero 2004; Godecharle, Nemery, and Dierickx 2018). The mapping of the studies concerning the university-industry relationship and the identification of the positive and negative factors in our scoping review could benefit the development of educational programs that would be tailored to the needs not only of researchers but also to the representatives of the industry.

Strengths and limitations

The main strength of this study is a robust and comprehensive literature search and screening that included both peer-reviewed and gray literature publications. This enabled us to provide a comprehensive map that can highlight areas in which the research integrity community should focus. Peer-reviewed documents from bibliographic databases were searched based on a sensitive search strategy (to increase the comprehensiveness) and screened by multiple researchers, following the JBI three-step screening methodology. This enabled us to obtain various documents related to positive and negative factors influencing the RI implementation that originated from different geographic areas, disciplinary fields, and research organizations. Since we used a sensitive search strategy instead of specific, the search retrieved a large number of documents from bibliographic databases from which a great number were excluded in the process of screening. However, we believe that employing the sensitive search strategy was a better approach as a more precise search strategy would limit our search, and perhaps would not provide as many as possible articles relevant to our study aim. Although we employed the rigorous screening methodology, there is still a possibility that some articles were missed in screening the titles and abstracts. For example, if there were not enough information related to our study aim provided in the titles and abstract. Nonetheless, we believe that we minimized this risk by additionally screening the references of included articles which enabled us to find as many as possible articles related to our study aim. Another limitation for this study was the period to which the search was confined (1990–2021). The COVID-19 pandemic hit around the same time the scoping review was being done, thus missing studies on research misconduct that have arisen during this public health crisis. While the most infamous cases of misconduct seem to be related to issues handled by the studies analyzed in the present scope – such as pressure to publish, relations

with industry, conflicts of interest – future research will hopefully shed more light on whether new factors have come into play.

Conclusion

This scoping review has shown that factors which have a positive or negative impact on research integrity promotion and implementation are various and interrelated. Following this, organizations should not seek improvements only at one level, as these will most likely not yield effective and long-term benefits. Rather, it is necessary that all stakeholders work together with clear outlined responsibilities to achieve positive long-term changes. Researchers should follow written policies and guidance documents provided by research organizations. Research organizations should develop clear policies and provide educational courses tailored to the researchers' needs, establish research integrity bodies for investigating and sanctioning breaches of research integrity, and change the evaluation requirements. Together with funders and publishers, both researchers and research organizations should work toward making changes in the system of science by undertaking initiatives that will reduce pressures and competition, while promoting a culture of integrity, honesty, trustworthiness, and fairness. Given that the analysis of interventions for research integrity promotion showed no reliable evidence regarding the effectiveness of different interventions, future research should address gaps by employing a more robust approach in order to examine what can encourage and positively impact research integrity promotion and implementation on all levels.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Protocol registration

The protocol was registered at the Open Science Framework (OSF) on 11 April 2019. The registration is part of the SOPs4RI project WP3 component (Systematic reviews of practices and research cultures) registration (available at https://osf.io/saj4u). The protocol is available at https://osf.io/caefg/.

Data availability statement

The search strategies used to obtain documents for the analysis are available in Appendix 1. The list of publications included in the final analysis and the taxonomy of identified factors are available in Appendix 2. The list of all documents used in the analysis and data that support the findings of this study are available at Open Science Framework (OSF) as Online Supplementary Material.

The data are available at the link below:

https://osf.io/zcymr/?view_only=111625efcbd04f2aa4ac373c8993a172.

Authors' contributions

RR developed the protocol for the study, performed the pilot screening and data screening, full-text analysis, data charting, risk of bias assessment and synthesis of all data sources, interpreted the results, and wrote and edited the manuscript.

ARE edited the protocol, performed the pilot screening, data screening of the documents from the bibliographic databases, and contributed to the revision of the manuscript.

WK edited the protocol, performed the pilot screening, data screening of the documents from the bibliographic databases, and contributed to the revision of the manuscript.

IB developed and edited the protocol, performed the full-text analysis, data charting, and contributed to the revision of the manuscript.

AM developed and edited the protocol; was a third researcher for decision in the process of screening and analyzing the data, performed the risk of bias assessment, interpreted the results, revised the manuscript and supervised the research.

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