DOI: 10.53116/pgaflr.7721

Insights on the Socio-Economic Impacts of Research Misconduct

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Submitted: 04 October 2024 | Accepted: 04 November 2024 | Published online: 11 December 2024

Abstract: Research misconduct (RM) and questionable research practices (QRPs) have a considerable impact on researchers, economy and society. Using a socio-economic impact assessment methodology, this article identifies and assesses their impacts. The objective is to help support the measures developed to promote research ethics and research integrity principles through shared responsibility (individual and institutional) and improve education and training. The article presents recommendations for policy and future research as part of a cohesive framework that takes socio-economic impacts into account. This qualitative study advances and updates current knowledge on the impacts of RM, enriching existing research by introducing new insights, especially regarding socio-economic dimensions, affected stakeholders, and the relevance and significance of these impacts.

Keywords: impacts, impact assessment, questionable research practices, research integrity, research misconduct, socio-economic impact

1. Introduction

Research misconduct (RM) and questionable research practices (QRPs) have a considerable adverse impact on researchers, economy and society (Hussinger & Pellens, 2019; Kim et al., 2018; Michalek et al., 2010; Stern et al., 2014). RM can have a major impact on society because it can compromise the integrity and reliability of scientific knowledge, which serves as a foundation for decision-making in various sectors. When data is falsified, fabricated or plagiarised, it can lead to incorrect conclusions, decisions and behaviours, and undermine public trust in research, healthcare, technology and public policy. RM includes fabrication (making up data or results and recording or reporting them), falsification (manipulating research materials, equipment, or processes, or changing or omitting data or results such that the research is not accurately represented in the research record) and plagiarism practices (appropriation of another person's ideas,

processes, results, or words without giving appropriate credit). QRPs capture practices that do not strictly fit definitions of RM, might be problematic and damaging in some contexts and compromise research and its integrity (e.g. selective reporting) but may be legitimate in other contexts (Michalek et al., 2010). Although RM *per se* has a major impact and consequences on the society and the research environment (Couzin, 2006), QRPs such as p-hacking (i.e. performing multiple statistical analyses in search of a 'significant' P value), HARKing (i.e. hypothesising after the results are known) and poor data management can impact the quality of research studies and as a result have consequences for the research environment (Gopalakrishna et al., 2022). RM carries with it sanctions but QRPs may go unnoticed and unpunished. Socio-economic consequences are often overlooked during RE/RI training sessions and by major training programmes available (Pizzolato et al., 2020) and only marginally addressed in terms of assessment of RM and QRPs (Shen et al., 2024; Wible, 2023).

Using a socio-economic impact assessment (SEIA) lens and methodology (Rodrigues & Rituerto, 2022), this article identifies and assesses the impacts of RM and QRPs. This approach to evaluating the effects of RM that considers systemic factors has strategic value in providing a combined (in terms of looking at diverse socio-economic criteria and affected stakeholders) and 'bigger picture' (understanding at research community and societal levels) approach to addressing and mitigating RM. It supports the measures developed to promote research ethics and research integrity principles through shared responsibility (individual and institutional) and improve education and training. The article also presents some recommendations for policy and future research and action. This qualitative study adds to and updates the state-of-the-art on the impacts of RM and complements existing studies (e.g. as carried out in the DEFORM project, European Commission, 2016) by developing and bringing together new knowledge, particularly by providing a clear and detailed overview on the socio-economic aspects, affected parties and the relevance and significance of the impacts in a single place. The findings and analysis presented here will be useful criteria for further quantitative research and assessments, and to aid decision-making and training in research ethics and integrity. Understanding socio-economic impacts of RM ensures that measures for mitigation of RM are effective and efficient, synergistic, and not disconnected from societal needs or the consequences of RM and QRPs.

Socio-economic impacts in the context of this study cover impacts relating to or concerned with the interaction of or combination social and/or economic factors. There are a range of social (impacts on people and communities) and economic impacts (e.g. impacts on the economy, business, investment, markets). RM and QRPs have a diversity of impact types, affected stakeholders, directions, magnitudes, duration and likelihoods of occurrence.

The article first outlines the methodology underpinning the study, followed by presenting the results of the impact identification (impacts identified, drivers, stakeholders affected, mitigation measures) and evaluation stages of the study. Then, it discusses the results and outcomes, and finally, offers recommendations for future research and action.

2. Methodology

This study was part of the EU-funded BEYOND project (BEYOND, s. a.) that focuses on promoting research ethics and integrity (RE/RI) and preventing research misconduct (RM) by accounting for systemic and institutional context alongside individual researchers' behaviour. The study used a mixed methodology approach combining a review of peer-reviewed and grey literature with stakeholder consultations to provide an overview of wide-ranging consequences of RM and QRPs.

While this article relies on the concepts and process advanced in Rodrigues and Rituerto (2022), it differs in application: in this article we apply a socio-economic lens to identify and analyse RM and QRP which are different in nature from new and emerging technologies. Nonetheless, this article benefitted from drawing from the approach and the guidance provided there, especially in terms of the steps of the SEIA (here, a structured way of showing the advantages and disadvantages of RMs and QRPs for society as a whole and for various parties). The novelty of this article lies in its tailoring and application to RM and QRP impacts. We first performed a scoping review on the topic to identify different socio-economic impacts of RM and QRPs (which were classified thus initially), then carried out a two-step validation to confirm the main outcomes of this study. The scoping review of peer-reviewed and grey literature was done between January and April 2023. The second stage involved consultation with diverse stakeholders (e.g. project partners and external RI experts, May–June 2023). A draft consultation paper was shared, and ten responses were received (Rodrigues & Pizzolato, 2024, Annex 1). Consultation participants were well balanced in terms of gender (Male: 5, Female: 5). One participant was a project partner, three were members of the stakeholder advisory board (SAB) of the project and six were external experts. The experts were chosen based on their RI/RE expertise and research studies previously conducted by them on the topic. Responses were processed and fed into the scoping review done in the first stage. Respondents then verified their input and provided some additional insights regarding additional consequences of RM. During the stakeholder consultation, participants confirmed the information gathered during the literature review regarding the consequences of RM and the affected groups.

Following the impact identification stage, we carried out an impact evaluation (June–July 2023) and used this to develop a list of recommendations for mitigation of RM and QRPs (Rodrigues & Pizzolato, 2024, Annex 2). The study team held a workshop on 12 September 2023, in which five selected stakeholders participated (Female: 4, Male: 1). The objective was to share, discuss and validate the evaluation results of our study on the socio-economic impacts of RM and prioritise recommendations for action. Three stakeholders had already been involved in the first impact identification consultation, which helped to maintain a certain degree of consistency and continuity. Two were involved for the first time, and this provided us with fresh perspectives. The participants had different profiles (e.g. researchers, research managers, topical expertise: economics) and affiliations (public and private research organisations).

2.1. Impact identification

2.1.1. Peer-reviewed materials

Design and scope

We conducted a scoping review of peer-reviewed literature to understand the socio-economic consequences and impacts of RM and QRPs. This allowed us to identify key concepts in existing literature on this topic (Arksey & O'Malley, 2005; Peters et al., 2015). In addition, it allowed an initial assessment of the scope of the literature, focusing on identifying research findings and evaluating the quantity and quality of the literature regarding study design, actors involved and other important features (Grant & Booth, 2009). We followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Page et al., 2021). This study provides an overview of the various socio-economic consequences of RM and QRPs. It did not undertake an in-depth quantitative financial and/or sociological analysis and therefore, neither quantifies the amount of wasted financial resources nor the social disruption. Such quantification could be a good opportunity for future research with the right tools and access to data (data on RM and QRPs is not generally openly or robustly available) within different research domains.

This study focused on 'research' in general and not on one particular sector or domain. We acknowledge that there are diverse approaches in public and private sector research, however, limiting the scope for this study would have affected the breadth of the insights we could have derived and any cross-learnings, given there is a lot of overlapping work between sectors. This study does not delve into each identified impact or mitigation measure, or how they can prevent RM and QRPs, in depth, as this is outside its scope (too many to be covered individually, especially as it was not anticipated in the study planning and resources allocated).

Search strategy and inclusion criteria

We searched three different databases: PubMed, Web of Science and Science Direct. Strings referring to the socio-economic consequences and referring to the topic of RI were merged in a single search string (Table 1).

The results from the different databases were merged and the duplicates were deleted. Screenings of titles, abstracts and full texts were conducted to determine if the retrieved papers met the inclusion criteria. After selecting the final 59 manuscripts, a snowballing process was performed to enrich the pool of selected papers (Greenhalgh & Peacock, 2005) (Figure 1). This snowballing process added two more articles, giving us a total number of 61 manuscripts to analyse (see the listing in Rodrigues & Pizzolato, 2024, Annex 3).

This review included peer-reviewed literature (empirical, theoretical, commentary) published in English. The search was performed in January 2023 and double-checked in April 2023. The study included literature focusing on the socio-economic consequences of general RM at the individual and collective levels.

Table 1
Search strategy

Database	String 1	String 2	String 1 + String 2	Number of publications
PubMed	"Research misconduct" [All Fields] OR "scientific misconduct" [MeSH Terms] OR "questionable research practice*" [All Fields] OR "research integrity" [All Fields]	(((((**consequence***) **OR (impact***)) **OR (social consequence***)) **OR (economic consequence***)) **OR (social impact**)) **OR (economic impact**)	(((((**"research misconduct"**) **OR (research misconduct [MeSH Terms]**)) **OR (**"**questionable research practice***"**)) **OR (**"**research integrity**"**)) OR (research integrity [MeSH Terms]**)) **AND** ((((((**consequence***) **OR (impact***)) **OR (social consequence***)) **OR (economic consequence***)) **OR (social impact**)) **OR (economic impact**))	488
Web of science	**research misconduct** (Topic) or **"research integrity"** (Topic) or **"questionable research** practice*" (Topic)	**consequence*** (Topic) or **impact*** (Topic) or **"social consequence*"** (Topic) or **"economic consequence*"** (Topic) or **"social impact*"** (Topic) or **"economic impact*"** (Topic)	**String 1 AND String 2** and **English** (Languages) and **Article** or **Other** or **Review Article** or **Editorial Material** (Document Types)	1,129
Science Direct			("research misconduct" OR "questionable research practices" OR "research integrity") AND ("social consequences" OR "economic	108
			consequences" OR "social impact" OR "economic impact")	

Source: compiled by the authors

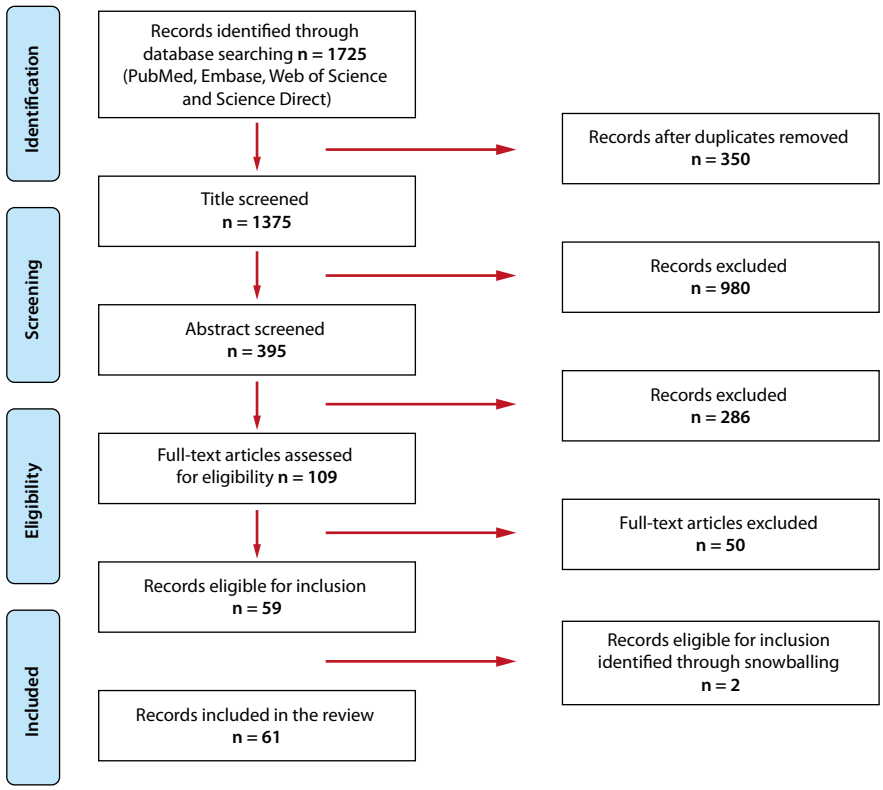

Figure 1
PRISMA extraction chart

Source: compiled by the authors

2.1.2. Grey literature

A non-comprehensive/limited review of grey literature was carried out to supplement the search of peer-reviewed literature and capture information on the socio-economic consequences of RM. The searches were performed and updated between January–March 2023. Search engines such as Google were used along with specific targeted searches of research organisations websites, policy makers at the EU, international and national level (European Commission, UNESCO, Grant et al., 2018; WHO, Grant & Booth, 2009; OECD, Peters et al., 2015; Bruton et al., 2019), research funding organisations/associations thereof (Science Europe, Wellcome, U.S. National Science Foundation, s. a.; see Science Europe, 2015a and 2015b), the Embassy of Good Science, EU-funded projects (DEFORM, see Hagberg, 2020 or RRI Tools), open access repositories such as Zenodo. Search terms used included: research/scientific misconduct, socio-economic, questionable research practice. These complementary strategies were

used to minimise the risk of omitting relevant sources. Since abstracts are often unavailable in grey literature documents, executive summaries or table of contents were screened where available. Screening of documents' full text followed using search terms including *impact, consequence, social, economic*.

A total of 18 results (wikis/articles/reports/project deliverables/policies/books/white papers/briefing papers/webpages/guidance) were shortlisted for the study. Work not directly or explicitly dealing with socio-economic consequences was excluded.

3. Results

This section provides information regarding the different socio-economic consequences of RM and QRPs and an overview of the stakeholders affected. An assessment of the consequences in terms of duration, magnitude and occurrence following the guidance in Rodrigues and Rituerto (2022) is also presented.

3.1. Impacts identified

Our literature review identified a diversity of socio-economic impact categories relating to RM. The review identified mainly negative impacts, and two cases of positive impacts (ones that have a beneficial direction of change, i.e. development of automated monitoring tools to prevent fraud and other solutions such as pre-registration and pre-printing). We present the socio-economic impacts identified using the following broad categories: trust; education; careers and employment; business and investment; health and well-being; research/scientific endeavour, progress, and innovation; standards, regulation and policy and publishing (Figure 2). These categories were chosen based on the themes that emerged from the literature review. Figure 2 below summarises the findings of the impact identification (where do the impacts fit). In the figure, the percentages refer to how many articles mention a particular category in the literature analysed. We do not intend to draw quantitative conclusions about the occurrence of consequences. The data presented should not be interpreted to mean that any degrees of impact are directly proportional to the number of papers on the matter. Annex 3 (Rodrigues & Pizzolato, 2024) presents the detailed results of the identification.

During the stakeholder consultation, participants confirmed the information gathered during the literature review regarding both the consequences of RM and the affected groups.

The impact drivers for RM and QRPs include challenging institutional culture/environment, precarious jobs, lack of supervision of researchers and research activities, inadequate training, competitive and career pressures, personal circumstances, individual psychology (including self-control issues) and lack of deterrence mechanisms to prevent RM and QRPs from occurring (Andorno, 2021; Holtfreter et al., 2020).

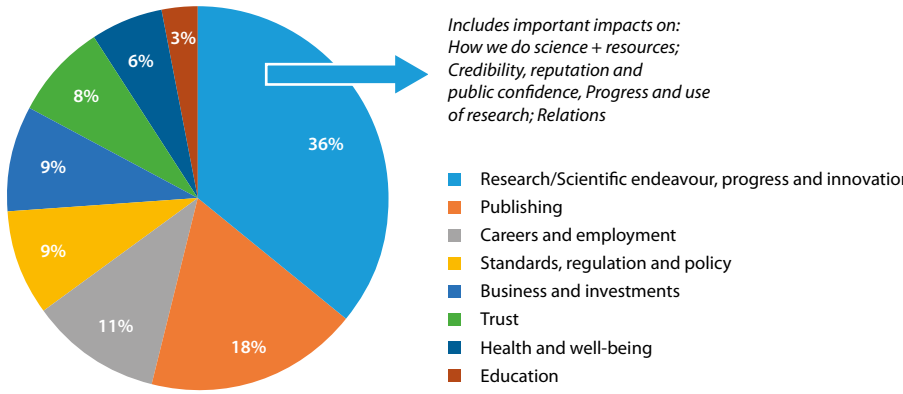

Figure 2
Impacts identified

3.2. Stakeholders affected by RM and QPRs

Affected parties (across the public–private spectrum) include administrators, authors, businesses and enterprises, educators, family, funders of research, medical professionals, patients (relatives), perpetrators, policy makers, public health bodies, publishers, research collaborators, research participants, research performing organisations, researchers (all sectors) including whistleblowers, students, the scientific community and society (the public). These affected parties may encounter both direct or indirect impacts depending on the context and the nature of their involvement or closeness to RM in question. All the affected parties are impacted by decisions based on flawed research and data. Although the list was compiled by analysing the peer-reviewed and grey literature mentioned above and confirmed via stakeholder consultation, it is non-exhaustive. Factors that might have affected this include limitations in the available/openly accessible literature, limitations of the consultation process and/or the complexity (information about RM and QRPs is not well- shared and publicised) and the scope of the topic.

3.3. Applied/prescribed/recommended mitigation measures identified

Mitigation measures are actions taken to minimise or reduce possible negative impacts, their severity and improve beneficial socio-economic impacts. Our research identified the following mitigation measures (from the literature review and stakeholder consultation exercise) that can be taken to minimise the negative impacts of RM. We have classified these measures into three categories (though there may be some overlaps, i.e. some measures might fall within one or more categories depending on the context): *preventative* (measures to prevent or reduce potential impact before it occurs); *corrective* (measures to reduce the impact to an acceptable level); and *compensatory* (measures that are applied when the other two fail and to compensate for unavoidable harmful impact) (see Table 2).

3.4. Impact evaluation

Impact evaluation assesses the relevance of impacts using impact significance methodology that helps evaluate and decide what is important, desirable or acceptable (Rodrigues & Rituerto, 2022). The relevance of the impacts of RM was assessed in relation to multiple criteria including affected parties and industries/sectors, direction of the impact, magnitude, duration and likelihood of occurrence. Since quantitative data was not easily available, we took a qualitative approach based on assessment by the authors drawing from the identification study, a review of secondary data, the authors' expertise and judgment, and validation of the conclusions with project partners and experts via the online workshop conducted on 12 September 2023 that discussed the results of our evaluation, reviewed the recommendations, and identified gaps.

Table 2
Mitigation measures

Preventative measures	**Corrective measures**	**Compensatory measures**
• Awareness measures • Careful study design • Clear authorship criteria • Clear standards and records • Clearly defined exclusion criteria • Conflict of interest disclosures • Detailed protocol writing • Fraud detection measures • Good role models • Good scientific practice • Openness to criticism and feedback • Peer review • Power analysis • Replicability testing • Researchers taking responsibility, self-testing • Rewarding quality over quantity • Due diligence requirements for research organisations • Training and guidance • Transparency	• Altering the rewards system • Audits • Continued training and sensitisation • Correcting scientific records • Fines/sentences/ licence revocation/ criminal sanctions • Formal investigation of claims and allegations • Integrity hotlines/reporting safe spaces • Mentoring and oversight • Open discussion of issues • Peer review • Power analysis • Research integrity officers • Taking retractions seriously • Transparency	• Awareness measures • Interventions to change research culture • Evaluation and review of corrective measures • Improving screening and peer review processes • Institutional/national policy review and reform – systematic, social and cultural • Policy interventions • Pressure reduction measures • Preventing publication of questionable materials • Public education • Strengthening fines/ sentences/sanctions • Transparency • Training • Whistleblower counselling

Source: compiled by the authors

This section presents the assessment of the identified impacts against the following criteria: (Rodrigues & Rituerto, 2022).

- *affected parties* and industries/sectors
- *direction* (negative/positive)
- *magnitude* (High: within the limits of the highest order of imaginable impacts; Medium: Impact is real but not substantial in relation to other impacts that might take effect within the bounds of those that could occur; Low: Impact is of a low order and therefore likely to have little real effect)
- *duration* (Short term impacts occur over a few months or for a defined period and are/may be of minor importance in the long time frame; Medium term impact refers to impacts that can be measured in months or few years [e.g. up to ten years]; Long term impacts are impacts that will last for over ten years)
- *likelihood of occurrence* (Rare: may occur in exceptional conditions/circumstances; Unlikely: such impacts that have a very low chance of occurring now or in the future but could occur; Possible: these are impacts that are possible and might occur; Probable: these are impacts that are very likely to occur; Certain: are impacts that will occur)

As all impacts would in some way affect 'society' at large, using 'society' as a category would be redundant. Rather, we focus on the specific actors and groups affected.

The evaluation was carried out in three rounds. In the first round, the study team evaluated the impacts based on their background knowledge, judgement and desktop research. Counterchecks of each other's work were also run (July 2023). In the next round, the study team checked the collated impacts against the peer-reviewed and grey literature from the identification stage and screened identified impacts for affected parties and direction of impact (July 2023). In the final round, the team ran further validation checks using desk research to identify gaps in our findings – this enabled us to add specific stakeholders and information on the sectors/industries affected. These findings were summarised and shared with experts in the 12 September 2023 workshop.

The tables below present the results of our evaluation – impacts are ordered in accordance with the likelihood of occurrence (certain to rare; S/E = Social/Economic). The different subsections indicate specific impacts for the different broad categories mentioned above and in Figure 2.

3.4.1. Trust impacts

Although the socio-economic impacts related to 'trust' manifest more generally in relation to all scientific disciplines, they have been flagged specifically in relation to the following sectors and industries: Private science/biotechnology (Glenna & Bruce, 2021); climate and environment (Leiserowitz et al., 2013); medical/healthcare (Boetto et al., 2021; Garfield, 1987; Grimes et al., 2018; Holbeach et al., 2022; Kim & Park, 2013; Michalek et al., 2010). This could be either because these sectors might be more prone to RM, or because relatively more effective mechanisms exist for identifying when

it occurs given their more stringent legal requirements and regulatory control, or a mixture of both factors (Table 3).

Table 3
Trust impacts

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Harm/damage to trust in science and/or research and researchers	Scientific community; researchers; research participants	Negative	High	Short term and long term	Certain
Adverse impact on trust of public in science	Individuals, media	Negative	Medium to high	Medium term and long term	Certain
Opportunity costs of loss of trust/goodwill by the public and damage to reputations	Laboratories/ research institutions, the public; public-private partnerships	Negative	Medium	Short term	Probable
Adverse impacts on the presumption of innocence	Researchers, research-related staff	Negative	High	Short and long term	Probable
Adverse impact of trust of policymakers in science	Policy makers. Researchers/ scientists; research funders	Negative	Medium	Medium term and long term	Possible
Distrust in healthcare	Patients, doctors	Negative	Medium	Medium term and long term	Unlikely
Negative impact on forensic reports	researchers, research participants, institutions, judicial bodies	Negative	Low to medium	Short to medium term	Rare

Source: compiled by the authors

3.4.2. Education impacts

The socio-economic impacts related to 'education' manifest in the medical/healthcare (Chalmers, 1990; Dooley & Kerch, 2000; Dougherty, 2019; Frias-Navarro et al., 2021; Guraya et al., 2016; Li et al., 2022; Moore et al., 2010; Krishna & Peter, 2018; Rowbotham, 2008; Stern et al., 2014) and educational domains (Eckstein, 2003) (Table 4).

Table 4
Education impacts

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Costs of security measures for administering national examinations	Educational institutions	Negative	Low	Short term	Probable
Misinformation in medical literature leading to preventable illnesses and/ or loss of life	Patients, researchers, doctors	Negative	High	Short term/ medium term	Possible

Source: compiled by the authors

3.4.3. Career and employment impacts

The socio-economic impacts related to 'careers and employment' appear prevalent in the following sectors and industries: STEM disciplines (Science, Technology, Engineering and Mathematics) (Roy & Edwards, 2023); health and life sciences (Stavale et al., 2019). This might be as these are more widely 'regulated' (with legal, ethical and research integrity requirements) than SSH disciplines (Social Sciences and Humanities) (though efforts to improve requirements and training has increased and is growing (Pickett & Roche, 2018), especially given the interdisciplinarity of research and the use of new technologies e.g. generative AI) (Table 5).

Table 5
Career and employment impacts

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Impact on career (losses of title, job, awards, degrees, denial of promotions/tenure, debarment, dismissal, participation prohibitions, incarceration), reputation and income, of the ones committing misconduct	Researchers, research-related staff; research organisations; investigators; administrators	Negative	High	Short term, medium term and long term	Certain (where cases occur)
Career and ostracism impacts for whistleblowers	Whistleblowers, colleagues	Negative	Low to high	Medium to long term	Probable
Exclusion from grants	Researchers, research organisations, collaborators	Negative	Medium	Short to medium term	Probable
Consequences on collaborators	Research collaborators; public-private partnerships	Negative	Low	Short term	Possible
Risk of stigmatisation through false positives and consequences for careers	Accused/ implicated researchers	Negative	Medium	Short term/ Long term	Possible
Competitive disadvantage for researchers who abide by the rules	Researchers	Negative	Low	Short term	Rare
Increased research misconduct controls would deter talented researchers, leading them to opt for less heavily regulated or scrutinised career paths	Researchers	Negative	Low	Long term	Rare

Source: compiled by the authors

3.4.4. Business and investment impact

The socio-economic impacts related to 'business and investment' were flagged as heightened in the biomedical sciences (Morreim, 2021) (Table 6).

Table 6
Business and investment impacts

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Investigations and punishment of the professionals involved	Accused parties, perpetrators (researchers); investigators and disciplinary bodies; families [all]	Negative	High	Short, medium and long term	Certain
Financial costs of the investigation	Research organisations	Negative	Medium	Short and medium term	Certain
Costs of remediation of misconduct	Research organisations	Negative	Medium	Medium term	Probable
Closure of labs	Research organisations	Negative	Low	Short term	Probable
Increase in litigation and legal costs	Researchers, research organisations; legal professionals	Negative	Medium	Short to medium term	Probable
Organisational brand damage due to bad publicity	Research organisations	Negative	Medium	Short term	Probable
Development of automated monitoring tools to identify fraud	Research organisations	Positive	Low	Medium term	Probable
Creation of need to garner additional resources to investigate and/or mitigate research misconduct	Research organisations	Negative	Medium	Medium term	Possible

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Drying up of/withdrawal research grants and funding	Researchers, research organisations	Negative	High	Short to medium term	Possible
Wastes important national assets and talent	Economy; government	Negative	Low	Short term	Possible
Sales losses	Research organisations	Negative	Low	Short term	Possible
Talent losses	Research organisations	Negative	Low	Medium to long term	Possible
Associated/significant financial costs	Funding agencies/bodies and research institutions	Negative	Low	Medium term	Rare
Serious implications for the scale of (dis)continuing public investment	Economy; government	Negative	Low	Medium term	Rare

Source: compiled by the authors

3.4.5. Health and well-being impacts

The socio-economic impacts related to 'health and well-being' are notably prevalent and have been flagged in relation particularly to the medical/healthcare sector (Barde et al., 2020; Boetto et al., 2020) (Table 7).

Table 7
Health and well-being impacts

S/E Impact	Affected parties and industries/ sectors	Direction	Magnitude	Duration	Likelihood of ccurrence
Impact on prescribed medical care	Patients, doctors, nurses and other caregivers	Negative	Medium	Short to medium term	Probable
Impact on individual well-being	Individuals, carers, families	Negative	Low to medium	Short to medium term	Possible

S/E Impact	Affected parties and industries/ sectors	Direction	Magnitude	Duration	Likelihood of ccurrence
Adverse effect on/harms patients due to bad clinical decisions	Patients, clinicians	Negative	High	Short to medium term	Possible
Financial consequences for health systems	Patients, doctors, healthcare organisations	Negative	Low	Medium to long term	Unlikely
Harm and indirect costs to society due to belief in false results	Individuals	Negative	Medium	Medium to long term	Unlikely
Harm to environment	Planet, plant and animal life	Negative	Low	Medium term	Rare

Source: compiled by the authors

3.4.6. Impacts on research/scientific endeavour, progress and innovation

The socio-economic impacts on 'research/scientific endeavour, progress and innovation' are wide-ranging and not specific to any one sector or industry. Again, here impacts might seem to be greater with regards to the medical/healthcare/biomedical sciences due to the nature of harms they could potentially result in and the risks to society in terms of human life and health (Tables 8 to 12).

Table 8
Impacts on how we do science

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Impact on the ability to reproduce and replicate studies in accordance with scientific principles	Researchers, academia	Negative	High	Medium to long term	Probable
Indirect costs of and implications of research by other scientists who have based their work on flawed data	Researchers, academia	Negative	High	Short to medium term	Probable

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Artificial enhancement of the methods and results of studies and impact on literature	Researchers, academia	Negative	Medium	Medium to long term	Possible
Inferior quality of findings	Researchers, academia	Negative	High	Short to medium term	Possible
Negative impact for following and related studies	Researchers, academia	Negative	High	Short to medium term	Possible
Effect on participation rate in studies	Researchers, academia, research participants	Negative	Low	Short term	Possible
Direct damage to science (false leads and time wasted)	Researchers, academia	Negative	Medium	Short term	Possible
Distortions or damage to the research record	Researchers, academia	Negative	Medium	Medium term	Possible
Inflation of false positives	Researchers, academia	Negative	Medium	Short term	Possible
Impact on translational research and other disciplines	Researchers, academia	Negative	Low	Medium term	Unlikely
Decrease in the value of research and value of PhDs and their contribution to research	Researchers, academia	Negative	Low	Medium term	Rare/Unlikely
Tolerance of further fraud	Researchers, academia	Negative	Low	Medium term	Rare

Source: compiled by the authors

Table 9
Impacts on resources: human, finances and time

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Risk to a given research project and/or impact	Other people involved in that project, including PhD students, postdoctoral researchers or support staff	Negative	Medium	Short to medium term	Probable

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Lost time	Researchers; research organisations, funders	Negative	High	Short term	Probable
Delays in processing grant applications	Research funders; researchers	Negative	Medium	Short term	Possible
Waste of funding resources and money invested	Research funders; government	Negative	High	Medium term	Possible

Source: compiled by the authors

Table 10

Impacts on credibility, reputation and public confidence in science

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Decline in the credibility of scientificanalysis and advice on issues that have important implications for society	Scientific community; research funders	Negative	Medium	Short to medium term	Probable
Adverse impact on the image and visibility of the field of study associated with misconduct	Scientific community	Negative	Medium	Short term	Probable
Harm to public confidence in research due to misconduct and lack of transparency in research findings	Scientific community	Negative	Medium	Short term	Probable
Distortion of the social perception of research	Scientific community	Negative	Low	Long term	Unlikely
Cynicism about the academic enterprise at large, professional integrity and the legitimacy of methodologies	Scientific community; researchers	Negative	Low	Short term	Rare

Source: compiled by the authors

Table 11
Impacts on progress and use of research

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Non-appropriation of research outputs by society or stakeholders and the ultimate waste of intellectual effort	Researchers; scientific community; public private partnerships	Negative	Medium	Short to medium term	Possible
Risk to the intellectual capacity	Organisations country/ international research consortia	Negative	Low	Medium term	Possible/Rare
Hinders/slows progress	Field/economy/ country affected	Negative	Low	Short term	Unlikely
Deprioritisation (for wrong reasons) of other potentially valuable research	Researchers; research funders	Negative	Medium	Short to medium term	Rare

Source: compiled by the authors

Table 12
Impacts on relations

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Degradation of relations	Scientists/researchers, senior researchers and students, and between researchers and agency programme managers	Negative	Medium	Short to medium term	Certain
Threat to research/scientific integrity	Scientific community	Negative	High	Short to medium term	Probable
Decline in research productivity	Researchers; research organisations	Negative	High	Short to medium term	Probable

Source: compiled by the authors

3.4.7. Impact on standards, regulation and policy

The socio-economic impacts on 'Standards, regulation and policy' were flagged in the medical/healthcare sector (Glenna & Bruce, 2021; Habib & Gan, 2013; Khadilkar, 2018; Moore et al., 2010) (Table 13).

Table 13
Impacts on standards, regulation and policy

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Misinformation/ deception	Policymaker, individuals	Negative	Medium	Short term	Possible
Poorly conceived public policies that impact the quality of citizens' lives	Government; individuals	Negative	Medium	Medium term	Possible
Negative influence on medical guidelines	Guideline developers; patients; policy makers	Negative	Medium	Short term	Rare
Adverse impact on/ undermining of government's ability to foster and promote research in a competent and responsible manner	Government; public research funders	Negative	Low	Short term	Rare
Civil disorder and violence due to controversy over fraud	Government; individuals	Negative	Low	Short term	Rare

Source: compiled by the authors

3.4.8. Impact on publishing

The socio-economic impacts on 'publishing' are widespread with regards to scientific publications in the medical/biomedical (clinical trials) and pharmaceutical fields. We note that the standards and requirements are more rigorous than other fields with better reporting and that the subject of research integrity still receives greater attention and discourse within the life sciences as compared to other academic fields (Ščepanović et al., 2021) (Table 14).

Table 14
Publishing impacts

S/E Impact	Affected parties	Direction	Magnitude	Duration	Likelihood of occurrence
Retractions of scientific publications	Authors; readers; publishers; researchers in biomedical field especially.	Negative	High	Short, medium and long term	Certain
Development of solutions e.g., pre- registration and pre-printing	Authors, publishers	Positive	Medium	Medium term	Certain
Financial costs resulting from the retraction of scientific articles	Funders and authors of retracted articles	Negative	Medium	Short term	Possible
Increase in peer-review and editorial/ publishing workload	Journal staff, reviewers, editors, publishers	Negative	Medium	Medium term	Possible
Delays in reviewing manuscripts	Reviewers, authors	Negative	Low	Short term	Possible
Brand damage	Publishers, author- associated research organisations	Negative	Medium	Short to medium term	Possible
Decrease in new articles	Scientific community	Negative	Low	Short term	Rare
Threat to the publishing process	Publishers, authors	Negative	Low	Short term	Rare
Loss of editorships	Editors	Negative	Low	Short term	Rare

Source: compiled by the authors

3.5. Mitigation measures: What should be prioritised and rationale

This section evaluates the identified mitigation measures (from the reviewed literature) using the results above, and especially what may be high magnitude, high certainty impacts, and provides guidance to reduce adverse impacts and improve the long term beneficial socio-economic effects. In line with the recommendations in Rodrigues and Rituerto (2022), the evaluation criteria included which impact is addressed, who benefits, ease of its implementation (using a scale of 1–3, where 1 is easy, 2 is moderate and 3 is hard/difficult), potential barriers (factors that hinder, obstruct or delay actions) and why the measures should be prioritised. To carry out this exercise, we looked at the identification results, conducted desk research, verified the results via internal reviews and presentation at the validation workshop on 12 September 2023.

Barriers, derived from general literature on implementation include cultural, economic, individual, organisational/institutional, legal and political barriers (Yang et al., 2021; UN Environment Programme, 2019; Department of Health, 2018; Agency for Healthcare Research and Quality, 2017) and implementation of research integrity measures (e.g. Golden et al., 2023; Troughton & Obasi, 2022; Evans et al., 2022).

The evaluation of preventative, corrective and compensatory measures (see Rodrigues & Pizzolato, 2024, Annex 4) highlights the critical importance of upholding research integrity and ethical standards within the scientific community.

The emphasis on measures promoting awareness, meticulous study design and clear authorship criteria serves to maintain the credibility and trustworthiness of research outcomes. Simultaneously, the implementation of corrective actions, such as altering rewards systems and conducting regular audits, will reinforce transparency and accountability. Additionally, the adoption of compensatory measures, including cultural shifts and the evaluation of past interventions, is essential to counter RM and ensure a robust research culture. Prioritising these diverse measures is instrumental to sustain the integrity, reliability and public trust necessary to advance scientific knowledge, innovation and progress.

4. Discussion

The study provided an overview of the possible consequences of RM and QRPs by clustering them in 8 categories: trust; education; careers and employment; business and investment; health and well-being; research/scientific endeavour, progress and innovation; standards, regulation and policy; and publishing. Moreover, it assessed the different impacts on diverse stakeholders.

At the core of scientific inquiry lies an implicit trust in the integrity of the research process and the individuals driving it forward. However, instances of misconduct, be it falsification of data, plagiarism, or ethical violations, inflict profound damage to this foundational trust. The ramifications extend to the broader scientific community, casting doubt upon the credibility of research outcomes and the reliability of those entrusted with their pursuit. The erosion of trust in scientific institutions through misconduct is penetrating the public consciousness and leading to scepticism and disillusionment (Baghramian & Caprioglio Panizza, 2022; Boyle, 2022). This phenomenon manifests itself in various areas, from aversion to evidence-based policy to scepticism towards public health initiatives and technological advances. The resulting societal disagreement hinders progress and innovation and undermines efforts for the common good. The consequences for people involved in misconduct are manifold and long-lasting. In addition to tangible consequences such as the loss of jobs, fundings, professional prestige, titles and honours, personal reputations (including associates found guilty of misconduct) are also permanently damaged. Careers that have been painstakingly built on a foundation of academic integrity are irrevocably damaged, with lasting effects on future opportunities and professional relationships. Furthermore, the psychological toll of the consequences of misconduct cannot be overstated, as those affected struggle with feelings of guilt, ostracism, harassment and existential issues. Dealing with allegations of misconduct requires careful investigation and adjudication processes, often conducted by institutional boards or peer review committees. These efforts require significant time, resources and emotional strength. The scrutiny to which the accused are subjected, the strain on professional relationships and the impact on family dynamics emphasise the gravity of these proceedings. In disciplines where empirical evidence forms the basis for the dissemination of knowledge, the retraction of suspect publications is a crucial factor in maintaining scientific rigour. However, such retractions take a heavy toll on authors, readers, publishers and research organisations (Memon et al., 2023). Authors face public criticism and reputational damage, readers struggle with diminished trust in scientific literature, and publishers walk a fine line between transparency and maintaining scientific integrity.

5. Recommendations

A preliminary set of recommendations was crafted through a detailed analysis of the study's findings (drawing from the literature review and the consultations). Subsequently, these recommendations were presented and discussed in the 12 September 2023 validation workshop with experts, as detailed in Section 2 (Methodology). The recommendations, outlined in Table 15 encompass the following key themes: 1. promoting a culture of integrity; 2. monitoring policy development; 3. enhancing investigation procedures and protective measures; 4. peer-review; and 5. providing the right incentives.

Table 15
List of recommendations

Theme	Recommendations
Promoting a culture of integrity	**Education**: Develop comprehensive training programs and workshops for researchers, faculty, students and administrative staff. These initiatives should cover topics such as research ethics, research methodology, plagiarism prevention, data manipulation and responsible authorship and generative AI. In addition, promote responsible mentorship and leadership practices. **Institutional support**: Establish an integrity committee that actively engages with researchers to discuss ethical dilemmas and best practices. Provide resources e.g. online courses, case studies, and informational materials to instil a sense of ethical responsibility. **Raising awareness**: Organise events (e.g. seminars, conferences and public talks) that highlight the importance of research integrity and its impact on society. Engage with media to spread awareness about the institution's commitment to ethical research.
Monitoring and policy development	**Policy development**: Develop guidelines and policies for research activities that outline expectations for data handling, authorship, conflict of interest and publication ethics. **Regular audits**: Implement a periodic auditing process to review research projects and ensure compliance with established guidelines. Use both internal and external auditors to maintain objectivity and thoroughness and reduce conflicts of interest. **Reporting mechanisms**: Develop a streamlined process to report potential misconduct or violations. This should include anonymous reporting options to encourage individuals to come forward without fear of retaliation.
Enhancing investigation procedures and protective measures	**Independent oversight**: Establish an independent committee responsible for investigating allegations of research misconduct. This committee should comprise experts from various fields with no conflicts of interest with the subjects under investigation. **Whistleblower protection**: Develop policies that safeguard individuals who report misconduct. Ensure confidentiality, non-retaliation and legal support and counselling for whistleblowers. **Timely investigations**: Clearly outline a step-by-step process for conducting investigations. This process should prioritise promptness and thoroughness while adhering to principles of fairness and due process.
Peer-review	**Transparency standards**: Develop guidelines for journal editors that emphasise transparent peer-review processes. This could include disclosing the review criteria to authors and reviewers and outlining the steps of the review process. **Reviewer guidelines**: Clearly communicate expectations to peer reviewers regarding unbiased evaluation, constructive feedback, and confidentiality. Encourage reviewers to provide detailed comments that can help authors improve their work. **Conflict resolution**: Establish a mechanism to address disputes between authors and reviewers. This could involve an independent mediator or a process to reconsider decisions based on objective criteria.
Providing the right incentives	**Assessment and metrics**: Include ethical metrics and indicators in the evaluation/ performance reviews of researchers, e.g. their involvement in ethics education, mentoring, responsible data management, contributions to peer review and reproducibility. **Professional development**: Provide incentives for researchers to engage in ongoing training and professional development in research ethics, integrity and responsible practices and conduct.

Source: compiled by the authors

The recommendations presented in this section are not novel. Various experts in research ethics and research integrity, both at the national and international levels, including relevant international organisations such as the ALLEA, see Stern et al., 2014; European Commission, UNESCO, DORA, see European Commission, 2016; European Network of Research Integrity Offices (ENRIO) and research projects (SATORI, see Garfield, 1987; SIENNA, DEFORM) have advocated these measures as effective means and valuable strategies to address RM and QRPs. However, what sets our approach apart is our attempt to underline the recommendations that address and help mitigate the identified socio-economic impacts. Usually, recommendations address a specific RI-related matter (e.g. incentives, publication, monitoring, etc.) and are seen in isolation from other recommendations on interconnected topics. Rather than viewing each recommendation in isolation, we have endeavoured to present them as part of a cohesive framework that takes socio-economic impacts into consideration. In doing so, we aim to show how these recommendations can synergise and complement each other, creating a more robust and effective strategy that combines mitigation measures based on impacts to address RM and QRPs. These recommendations can serve as a foundation to create and support guidelines and measures to enhance research ethics and research integrity. The presented recommendations are not explicitly pitched at any one organisation or country – this flexibility provides an opportunity for further customisation and enhanced specificity. Different stakeholders and organisations, including research institutions, funding agencies, publishers and organisations committed to research integrity can evaluate applicability, adapt, and put these recommendations into practice based on their specific needs, requirements and socio-economic impact circumstances.

6. Conclusions

This study provided a detailed review of the socio-economic consequences of RM and QRPs and thematically outlined some recommendations to enhance research ethics and research integrity. However, its scope was limited. Much more remains to be done, as shown by the core issues that emerged from our study and consultations with stakeholders as needs for further research.

RM, characterised by breaches of ethical standards and professional integrity within research endeavours, poses profound challenges to the integrity of scientific inquiry and the trust invested in its outcomes. Socio-economic consequences impact different stakeholders, challenging research progress, business investment, trust and posing a risk to the well-being of research participants and people whose lives are impacted by or subject to such research.

The need for a thorough review of traditional research methodology paradigms is emphasised by a forward-looking perspective that considers the rapid development and widespread application of generative artificial intelligence (AI) tools. These emerging technologies pose a formidable challenge to the conventional understanding and approaches of RM and the management of QRPs.

In addition, it is important to recognise the often overlooked but significant secondary impacts of QRPs. These include the impact on employees, the competitive disadvantage for researchers who adhere strictly to ethical standards, and the distortion of societal perceptions of research endeavours. Neglecting these impacts could have serious consequences and jeopardise the integrity and trustworthiness of scientific research. Furthermore, it is essential to recognise the indispensable role of the cultural context in shaping research practices and attitudes towards research quality. Promoting greater individual responsibility for research integrity means creating an environment that encourages ethical behaviour and accountability at all levels of the research enterprise. Navigating the complex terrain of RMs and QRPs requires a multifaceted approach that considers technological advances, cultural nuances and ethical imperatives. By fostering a culture of transparency, accountability and continuous improvement, the research community can effectively mitigate the risks posed by RMs and QRPs and ensure the credibility and trustworthiness of scientific research in a fast moving landscape.

Acknowledgements and disclaimer

The BEYOND Horizon Europe project – Beyond Bad Apples: Towards a Behavioural and Evidence-Based Approach to Promote Research Ethics and Research Integrity in Europe (2023–2025) is funded by the European Union, Grant agreement ID: 101094714. Trilateral Research is supported by UKRI Grant 10062742. This article and its contents reflect only the views of the authors and does not intend to reflect those of the European Commission or the UKRI. The European Commission or the UKRI is not responsible for any use that may be made of the information it contains. The authors would like to thank David Barnard-Wills and Ian Slesinger of Trilateral Research (reviews), the impact identification consultation participants (Sandra Bendiscioli, Martin Canter, Hugh Desmond, Kris Dierickx, Anja Gilis, Panagiotis Kavouras, Teodora Konach, Ana Marusic, Rita Santos, and Susanne van den Hooff), the validation workshop participants (Caroline Gans Combe, Anja Gilis, Panagiotis Kavouras, Dorota Lepianka and Susanne van den Hooff) and anonymous reviewers.

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