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the potential
of researchers

Research integrity:
a landscape study

Annex A:
Literature review

June 2020

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Research integrity: a landscape study

Vitae in partnership with the UK Research Integrity Office (UKRIO) and the UK Reproducibility Network (UKRN)

Commissioned by UK Research and Innovation (UKRI)

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The interpretations and opinions in this report are those of the authors and may not reflect the policy positions of UKRI.

Contents

This literature review provides further background to the 'Research integrity: a landscape study' report, as one of the data-gathering activities that informed both the development of the study itself and the interpretation of the results presented in the report.

Notable findings from the literature can be found within the main report, where relevant. However, this annex provides a fuller exploration of the literature which may be useful for those wishing to build on the study or place the results in a more detailed context.

1 Background

UKRI commissioned Vitae, in partnership with UKRIO and UKRN, to undertake a landscape study on research integrity. The project aimed to develop an understanding of the pressures and incentives in the research ecosystem, and how these affect researcher behaviour, in the context of research integrity and more broadly. This included the extent to which a range of stakeholders and different groups within the UK research ecosystem considered these incentives positive or negative.

Incentives are defined here as factors that encourage or motivate behaviour. They can be both extrinsic and intrinsic, and can operate both consciously or unconsciously. In addition, we assume that incentive structures can either incentivise good or bad behaviour, or disincentivise good or bad behaviour, and that these structures may have impacts in different ways at different levels. This annex describes: incentive structures at a range of different levels across the research landscape, from the global to the individual; how these incentives interact across the different levels and influence research integrity; and how well this is evidenced in the relevant literature. In this document we refer to the 'research ecosystem', to reflect the connected and dynamic nature of the factors at play within the research environment.

At the global level we look at the international or European initiatives that impact on the UK research ecosystem. We then consider how UK initiatives affect incentives and behaviours. We next consider the factors operating at an institutional or employer level that drive researcher behaviour. Throughout this annex, explore how the pressures and incentives may differ across disciplines and, finally, we consider the motivations of individual researchers and how these may impact on research integrity. We employ the definition of research integrity that appears in the Concordat to Support Research Integrity (see box below).

We also consider a range of cross-cutting factors that may modify the impact of these incentive structures on behaviour, including career stage, contract type and protected characteristics. At each level in the research ecosystem, we ask the following questions:

1. what drives the behaviour of researchers at this level?
2. what is the relationship between these drivers and research integrity?
3. how robust is the evidence for this?
4. what are the gaps in the literature?

1.1 Scope

The scope of the project was restricted to the research ecosystem in the UK and how this influences research integrity. We therefore focus here on country-specific data or reports, or studies relevant to researchers in the UK. We predominately focus on recent resources, mostly published since 2014, to identify the current state of incentives and primarily on the incentives relevant to researchers themselves and not to other members of the research community (such as higher education institutions (HEIs), funders and publishers). We acknowledge that pressures on HEIs, funders and publishers may drive the creation of some of these incentives.

In identifying relevant source materials we used a four-step search method:

- the identification of resources known to the project team, including journal publications and grey literature, surveys, reports and commissions
- a rapid literature review based on selective search criteria informed by the outcomes from two initial workshops and from stakeholder interviews
- reaching out to the UKRIO network and the UKRN for possible reference sources
- at each of these three steps, reverse searching any cited material within the above resources that were relevant to this review.

Defining research integrity (from 'The Concordat to Support Research Integrity', Hale et al., October 2019

Honesty in all aspects of research, including in the presentation of research goals, intentions and findings; in reporting on research methods and procedures; in gathering data; in using and acknowledging the work of other researchers; and in conveying valid interpretations and making justifiable claims based on research findings.

Rigour, in line with prevailing disciplinary norms and standards: in performing research and using appropriate methods; in adhering to an agreed protocol where appropriate; in drawing interpretations and conclusions from the research; and in communicating the results.

Transparency and open communication in declaring potential competing interests; in the reporting of research data collection methods; in the analysis and interpretation of data; in making research findings widely available, which includes publishing or otherwise sharing negative or null results to recognise their value as part of the research process; and in presenting the work to other researchers and to the public.

Care and respect for all participants in, and subjects, users and beneficiaries of research, including humans, animals, the environment and cultural objects. Those engaged with research must also show care and respect for the integrity of the research record.

Accountability of funders, employers and researchers to collectively create a research environment where individuals and organisations are empowered and enabled to own the research process. Those engaged with research must also ensure that individuals and organisations are held to account when behaviour falls short of the standards set by this concordat.

2 Global level

Academic research is a global enterprise, characterised by international collaboration and supranational organisations that form part of the global research system. These organisations include funders, publishers, learned societies and professional bodies, and other non-profit and for-profit organisations. The policies of these organisations can therefore have wide-ranging impact either directly, or indirectly through implementation by other organisations. There are several initiatives that have the potential to change behaviours relative to research integrity. While these initiatives are, by their 'global' nature, largely non-binding, universities, funders and publishers often adopt or reference these initiatives when developing policies that researchers must follow.

2.1 Open access

Science Europe, an association of 27 national research funding organisations and research-performing organisations, in collaboration with the European Commission and the European Research Council, launched cOAlition S[1] in 2018, which currently consists of 22 national and international funders. The aim of cOAlition S is to implement the 10 principles of Plan S, an initiative to transition to a fully open research environment by ensuring that all publicly funded research publications are immediately available in open access journals, in publishing platforms or through repositories. Likewise, the data underpinning these publications should be made available in research data repositories. The intent behind this is that research needs to be openly available to the whole research community, and society, so that it can be discussed, scrutinised, built upon and reproduced, where needed, to bring maximum benefit to research and society generally. The increasing adoption of open access by governments and funders has resulted in almost half of research papers now being open access (Piwowar et al., 2018; Wallach, Boyack & Ioannidis, 2018). The presumption is that open access publishing increases research integrity through transparency, although it is too early to be able to directly evidence this. Since 2015, Science Europe has also released workshop reports, briefing papers, roadmaps and other documents centring on research integrity in the context of Europe[2]. All of these stress the importance of trust: researchers being able to trust the research of other researchers and the process of research, and society being able to trust research outcomes.

2.2 Research ethics

The Declaration of Helsinki[3] (1964, last amended 2013), prepared by the World Medical Association, is another supranational initiative relating to research integrity. It was created to provide ethical guidelines for research on humans when no such document was yet widely accepted and used, and has formed the basis for many national and institutional ethics guidelines since its publication. It is now the de facto protocol for research on humans. Other global initiatives include the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity (2014)[4]; an international agreement aiming to ensure that the benefits of using genetic resources are shared equitably that has been adopted by the European

[1] https://www.coalition-s.org/
[2] http://www.scienceeurope.org/search/?text=research+integrity
[3] https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/
[4] https://www.cbd.int/abs/

Commission[5]. Their wide adoption may suggest they are successful in influencing researcher behaviour, although there is no direct evidence for this.

Contemporary research, however, comes with additional concerns that research ethics systems are still adapting to (such as big data, re-identification of anonymised data and commercial involvement of online platforms). For example, in collaboration with academics, Facebook conducted a study which never received formal approval from an ethics committee, instead relying on Facebook's terms and conditions, using data from nearly 700,000 people who had not provided explicit informed consent for participating in this study (Kramer, Guillory & Hancock, 2014). Publishers often serve as gatekeepers, for example by rejecting manuscripts that involve studies that lack approval from an ethics review board (see Springer[6]). However, in this instance, the publisher also failed to act as a gatekeeper to stop the publication of research conducted without ethical approval. There were clearly a number of failings in the process that allowed the initial research to be undertaken and its subsequent publication.

2.3 Assessment of researchers

Other international initiatives recognise the need to improve the assessment of researchers, a major influence on researcher behaviour, beyond the use of publications and citation indexes. These include: the San Francisco Declaration on Research Assessment (DORA)[7], a declaration developed by a group of editors and publishers in 2012 and signed by over 1,500 organisations and 14,000 individuals; the Leiden Manifesto, an outline of 10 principles to guide research evaluation (Hicks, Wouters, Waltman, De Rijcke & Rafols, 2015); the Open Science Career Assessment Matrix, a European Commission effort to create a framework for rewarding researchers who practice open research (European Commission: Working Group on Rewards under Open Science, 2017); and the development by the 6th World Conference on Research Integrity[8] of the Hong Kong Principles and accompanying paper, 'Assessing Researchers: Fostering Research Integrity' (The Lancet, 2019) targeted at institutional assessment of researchers for hiring and promotion. Although not necessarily focusing on research integrity, these initiatives aim to encourage various stakeholders to use metrics in a more nuanced way and to employ expert qualitative judgement of research outputs, including providing credit for good research practices. This more holistic approach to evaluation is posited as a fairer and more inclusive approach to evaluation that will change behaviours and research practices.

These global initiatives can influence researchers by designating explicit frameworks for what constitutes appropriate research practices that researchers, and institutions, can measure their practices against and know whether they are researching with integrity. While a clear causal chain is difficult to establish, they have the potential to change researcher behaviours on the ground. For example, a global framework to evaluate researcher outputs, may lead institutions to revise their evaluation procedures, which in turn may incentivise individual researchers to perform well on those measures (such as open research practices).

[5] https://ec.europa.eu/environment/nature/biodiversity/international/abs/legislation_en.htm
[6] https://www.springer.com/gp/authors-editors/authorandreviewertutorials/submitting-to-a-journal-and-peer-review/what-is-open-access/10285582
[7] https://sfdora.org/
[8] https://www.wcri2019.org/uploads/files/2019/Hong_Kong_Manifesto_v9.pdf

2.4 European research integrity initiatives

European-level initiatives can also influence research practices in the UK. Specific projects include the European Code of Conduct for Research Integrity (All European Academies (ALLEA), 2017), which provides a framework for research integrity that identifies both institutional and individual activities that drive good practice. Many countries are using the European Code as the basis for national policy and, while intended for a European audience, the Code has been taken up elsewhere in the world. It has now been translated into Japanese, Chinese, Russian, Arabic and Turkish as well as all of the EU languages.

European networks of relevant stakeholders that have been influential in supporting and shaping national practices include the European Network of Research Integrity Offices (ENRIO)[9]. This has 31 member organisations across 23 European countries who are 'practitioners' in research integrity governance and promotion within their countries, and aims to facilitate the exchange of knowledge and best practice within their network. This voluntary network was initiated by the UK and has provided a platform for pan-European discussion on research integrity and sharing country-specific processes relating to this. Its membership consists primarily of research integrity organisations. In partnership with the European Network of Research Ethics Committees (ENREC)[10], ENRIO initiated the European Network of Research Ethics and Research Integrity (ENERI)[11], which includes institutions and promotes communications across stakeholders with the aim of improving competence in relation to research integrity. Although these networks are raising the profile of research integrity, there is no evidence of whether their messages are reaching researchers and influencing their behaviours.

2.5 Responsible research and innovation (RRI) and open research

In Europe there are also efforts to ensure research is conducted in a way that is relevant to social values. There are multiple initiatives and resources under the banner of RRI (such as Promoting Societal Engagement in Research and Innovation[12], RRI Tools[13], RRI in Practice[14]), all of which promote the highest level of research integrity as an integral part of conducting research. A suite of research projects funded under the Science with and for Society (SWAFS) programme of Horizon 2020 aims to achieve better understanding of the drivers of poor research practice and to build research ethics, integrity and RRI frameworks, guidelines, standard operating procedures (SOPs) for research, training curricula and materials, and the online platform (The Embassy of Good Science[15]) relevant to all stakeholders in both medical and non-medical research[16].

The Evaluation of Research Careers fully acknowledging Open Science Practices (European Commission, 2017) provides guidelines on how to reward researchers for open and transparent research practices. Providing Researchers with the Skills and Competencies they need to Practice Open Science (European Commission: Working Group on Education and Skills under Open Science, 2017) describes the competencies needed to enable research to be conducted with a high degree of transparency, collegiality and research

[9] http://www.enrio.eu/about-enrio/
[10] http://www.eurecnet.org/index.html
[11] http://eneri.eu
[12] http://www.proso-project.eu
[13] https://www.rri-tools.eu
[14] https://www.rri-practice.eu/
[15] https://www.embassy.science/
[16] https://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-swfs_en.pdf

integrity. Increasingly, RRI and open research are being integrated into the EU Framework Programmes, which creates the potential to influence researchers' behaviours directly as they respond to funding calls and grant agreement requirements, although the ongoing monitoring processes by the European Commission are still generally weak.

2.6 Wider impact of national initiatives

In addition, the global, interconnected nature of the research ecosystem means that national policies can have global consequences. Some national funders support international projects, particularly in low- and middle-income countries, meaning that their policies influence researcher behaviour in those countries and may in turn shape the development of research culture at the national-level. For example, the UK government has a £1.5 billion Global Challenges Research Fund (GCRF) to support research to address the challenges faced by developing countries[17] and Wellcome funds major programmes in Africa and Asia[18]. The foundation evaluation of the GCRF drew upon the Research Quality Plus (RQ+) assessment process which emphasises that research should be useful to an end user (Ofir, Schwandt, Duggan & McLean, 2016). If novel research assessment tools that broaden the definition of research quality to include research effectiveness (such as the RQ+) become more widely used, they may have the potential to incentivise research integrity.

2.7 Journal impact factor (JIF) and publisher policies

The interconnected nature of the research ecosystem is illustrated by the universal use of JIF, which is still widely used (explicitly or implicitly) in promotion, hiring and funding decisions. JIF is calculated by Thomson Reuters, an international organisation, but is applied in different ways across countries, disciplines, funders and institutions. Given the widespread use of JIF, it may be the most significant global influence on researcher behaviour because of the prestige associated with a high-JIF publication.

Publication in high-JIF journals is one of the predictors of future success as an academic researcher (Van Dijk, Manor & Carey, 2014). High-JIF journals accept very few submitted articles (*Nature*: 7.6%[19]; *Science*: <7%[20]) and the perceived need to publish in high-JIF-journals may lead researchers to employ questionable research practices to increase their likelihood of acceptance. For example, "the criteria for publication of scientific papers in *Nature* are that they…are of outstanding scientific importance…reach a conclusion of interest to an interdisciplinary readership"[21]. Potentially, this may encourage researchers to report only a selected set of results (in other words engage in p-hacking) (Head et al, 2015). It may also disincentivise researchers from conducting replication studies or research that will incrementally increase knowledge.

There is nothing inherently wrong with JIF and high-JIF journals. Nevertheless, it is not an indicator of the value of individual papers because JIF is a property of the journal and not of the research. JIF represents the arithmetic mean of a highly skewed distribution (Lariviere et al., 2016). In other words, most papers have fewer citations than the JIF, some may have no citations and some will have many more than the JIF. Thus, JIF is less informative than article-level metrics when evaluating publications and researchers (Lariviere et al., 2016).

[17] https://www.ukri.org/research/global-challenges-research-fund/
[18] https://wellcome.ac.uk/what-we-do/our-work/programmes-and-initiatives-africa-and-asia
[19] https://www.nature.com/nature/for-authors/editorial-criteria-and-processes
[20] https://www.sciencemag.org/site/feature/contribinfo/faq/index.xhtml
[21] https://www.nature.com/nature/for-authors/editorial-criteria-and-processes

However, paper-level metrics (in other words next-generation metrics; Peters et al., 2017) are still not fully trusted or accepted by either the academic community or those who evaluate them.

Critically, the proximal drivers of behaviour will be organisational processes that assess researchers, such as funders' evaluation criteria, institutional promotion and hiring practices and disciplinary norms. While evaluations such as the Research Excellence Framework (REF) state that they do not consider JIF, other evaluators do so explicitly. For example, a recent study of universities from the US and Canada showed that 40% of research-intensive institutions mention JIF in their review, promotion and tenure documents, and 87% of these documents support the use of JIF in evaluations (McKiernan, Schimanski, Matthias & Niles, 2019).

Consequently, journals, particularly those with a high-JIF, have considerable potential to shape researcher behaviour, and in turn research integrity, through their policies. Many journals now include reporting checklists; for example, the journal *Psychological Science* introduced badges to incentivise open research practices[22]. These badges appear as coloured icons on the title page of a published paper which communicate to readers that the paper has openly available data and/or materials, and the research plan was pre-registered in a time-stamped file. The introduction of these badges was associated with a marked increase in data-sharing (Kidwell et al., 2016). Over 1,000 journals have also adopted the Transparency and Openness Promotion (TOP) guidelines (2015)[23], which provide a multi-level framework for how journals can improve their standards in relation to research integrity (Nosek et al., 2015). The Committee for Publication Ethics (COPE)[24], in existence over 20 years, provides leadership in thinking on publication ethics and practical resources to educate and support members worldwide from all academic fields, primarily editors but also publishers and related organisations, and has been instrumental in developing guidelines on publication ethics that are considered best practice internationally.

An increasing number of journals now offer a Registered Reports submission format[25], whereby research is evaluated on the basis of the importance of the question and the strength of the methodology, in contrast to conventional journal formats, where there is the potential for the work to be evaluated on the basis of whether the results are novel or deemed interesting. There is evidence across many disciplines that a high proportion of published studies report positive results and gain high citations (citation bias) (Chavalarias, Wallach, Li & Ioannidis, 2016; Fanelli, 2010; Duyx et al., 2017). In contrast, there is evidence that Registered Reports have a higher rate of null results than conventional journal formats suggesting that the incentive to perform questionable research practices to make one's work more 'publishable' has been removed (Allen & Mehler, 2019).

Many of these initiatives to encourage open research practices are promoted by organisations with an international scope, such as the Center for Open Science (COS)[26]. The COS provides a platform for researchers to share projects, pre-register studies & and upload preprints. While this organisation is based in the US, 48% of psychology researchers in the UK have an account[27]. The COS and other organisations interested in improving

[22] https://www.psychologicalscience.org/publications/badges
[23] https://cos.io/top/
[24] https://publicationethics.org
[25] https://cos.io/rr/
[26] https://cos.io/
[27] https://cos.io/blog/rise-open-science-psychology-preliminary-report/

research integrity are often funded through philanthropic donations, rather than standard funding mechanisms.

2.8 Ranking

Academic research institutions also compete at a global level on both implicit and explicit measures such as university league tables. League tables may incentivise institutions, as well as national-level organisations, to take actions that will increase their ranking, which may have a downstream effect on the pressures felt by individual researchers. Some of the ranking methodologies (such as Times Higher Education and QS World University Rankings) measure performance in both research and teaching in their evaluations and most of the research to date on league tables relates to teaching and enrolment. Additional studies are needed to understand how league tables shape academic research culture and impact research integrity.

2.9 Impact on researcher behaviours

These global influences differ in the extent to which they shape researcher behaviour and the amount of evidence available to support this association. Predominantly, they are weak forces and their influence depends on the extent to which they are collectively taken up by nations and, perhaps more importantly, funders and disciplines, which have stronger influences on researcher behaviours. For example, almost all medical researchers in the UK treat research participants according to the longstanding Declaration of Helsinki. The Declaration of Helsinki is non-binding at an international-level, but institutions, research ethics boards and publishers frequently require that researchers follow this declaration where applicable.

In contrast, most other global initiatives (such as DORA, Leiden Manifesto) have not (yet) become embedded in research cultures at lower levels (for example national, institutional and disciplinary). Furthermore, repercussions for failing to follow the guiding principles from these initiatives appear minimal or absent. There is little, if any, evidence of how these initiatives directly influence researcher behaviour in part because they are significantly more recent initiatives, but also because they need the collective engagement of all stakeholders to effectively change behaviour. It is therefore difficult to decipher the impact of these initiatives directly or indirectly on research integrity. Individual researchers may not be aware that influences at lower levels (for example institutions, funders and disciplinary norms) may stem from global initiatives.

The World Conferences on Research Integrity is a non-profit organisation that provides non-binding statements of good practice agreed at the international-level[28]. Some discipline-specific organisations and conferences also focus on research integrity (for example the Society for the Improvement of Psychological Science). Beyond producing statements, conferences can serve as a venue to share best practice and discuss ongoing issues.

3 UK level

While academic research extends beyond borders, many organisations and stakeholders influence research behaviour at the national level, including governments, funders, learned societies, professional bodies, industry partners and non-governmental organisations. In the

[28] https://wcrif.org/

UK the issue of research integrity has been a particular focus since the publication of the Concordat to Support Research Integrity (Hale et al., 2012). A list of the key recent UK reports relevant to research integrity is provided in Table 1.

3.1 Concordats

Universities UK (UUK) led the development of the Concordat to Support Research Integrity following the report of the UK Research Integrity Futures Working Group (Finch et al., 2010). This was developed in collaboration with the funding councils for England, Wales and Scotland, Research Councils UK (RCUK), the National Institute for Health Research (NIHR), the Department for Employment and Learning, and Wellcome. It aims to provide a comprehensive national framework for good research conduct and its governance. Research England has made compliance with the Concordat a condition to receive institutional research funding[29]. Similarly, the Scottish Funding Council requires universities to provide evidence of compliance with the principles of the Concordat[30] and the Higher Education Funding Council of Wales (HEFCW) asks universities to provide annual confirmation that they are compliant with the Concordat[31]. Many institutions, however, have not yet taken the actions that the Concordat recommended (House of Commons Science and Technology Committee, 2018; Wager, 2019), perhaps due to the lack of incentives and the absence of consequences for inaction. A few other Concordats have been developed in the UK that relate to research integrity, supporting the career development of researchers (Vitae, 2008), openness on animal research (Understanding Animal Research, 2014) and open research data (HEFCE, RCUK, UUK and Wellcome, 2016) (see Table 1).

3.2 Formula research funding and the REF

Government research funding is directly allocated to institutions through different mechanisms in different countries. Across 20 Organisation for Economic Cooperation and Development (OECD) countries surveyed (Techopolis, 2019), half of them used performance-based research funding systems, with the UK having the highest percentage of institutional funding based on performance assessment at 52%. Research England and the three other funding bodies in the devolved administrations evaluate research performance and allocate quality-related block funding through the REF[32]. Institutions are evaluated across Units of Assessments that map roughly onto academic disciplines, on the basis of research outputs, research impact and the research environment, which includes research integrity. Expert panels assess the quality of outputs, research environment and non-academic impact and the results are used to allocate formula research funding. This funding is not hypothecated (ring-fenced for specific expenditure) and HEIs can use it to further their institutional research strategies.

Given the substantial funding associated with REF performance, this exercise can influence the behaviours of institutions and in turn the practices of individual researchers (Nuffield Council on Bioethics, 2014). For example, the importance of impact case studies within the REF may incentivise institutions to focus on research where it is more likely to be able to

[29] https://re.ukri.org/research/supporting-research-integrity/

[30] http://www.sfc.ac.uk/web/FILES/committeepapers_06032019/RKEC_19_05_Research_Integrity.pdf

[31] https://www.hefcw.ac.uk/documents/publications/circulars/circulars_2015/W15%2031HE%20Memorandum%20of%20Assurance%20and%20Accountability.pdf

[32] REF takes place every 6-7 years and was preceded by the Research Assessment Exercise (RAE) (last run in 2008). https://re.ukri.org/research/research-excellence-framework-ref/

demonstrate real-world impact in a relatively short period. A survey of research-active academics showed that 15% of respondents reported that they were asked to change the focus of their research to accommodate the REF (Weinstein, Wilsdon, Chubb & Haddock, 2019). The REF explicitly attempts to incentivise quality rather than quantity by accepting a limited number of submissions, emphasising quality in the evaluation criteria and using expert evaluations of quality. Previous research evaluation exercises that prioritised quantity were associated with a decrease in the quality of outputs (for example Dyani Lewis, 2017).

More importantly, given the significance of the REF exercise, institutional behaviour adapts rapidly and strongly to the incentives it incorporates, for example by changing hiring policies to maximise the strength of their REF return (Jump, 2013). For instance, to submit a researcher to the REF 2014, the researcher needed to be employed on a contract specifying working hours of at least 20% full-time equivalent. In the years leading up to the 2014 REF, '20% contracts' increased by 63% among UK universities (Jump, 2013). There have been changes in subsequent REF criteria to counter this practice.

The REF 2014 guidance specifically stated that sub-panels would not use JIFs or rankings in assessing the quality of research outputs and discouraged institutional use of citation information to inform the selection of staff or outputs. However, there is evidence that, in some cases, a focus on JIF and other metrics still dominated internal REF processes at individual institutions (Taylor & Wedel, 2015). A survey of researchers concluded that the REF was thought to be a key driver of pressure to publish in journals with a high-JIF and that many UK researchers were unaware or untrusting of the instruction given to the REF panels to make no use of JIF in assessing the quality of research outputs (Nuffield Council on Bioethics, 2014). The guidelines for the REF 2021[33] (again) state that evaluators will not use JIF in their assessment. The REF open access policy (introduced in April 2016) also requires that all journal articles and conference proceedings submitted to the REF are made available open access (respecting any embargo periods).

3.3 Responsible research metrics

Concerns around the inappropriate use of JIF in measuring research quality have led to initiatives such as DORA, although a recent survey of British institutions showed that 75% had no research metrics policy and 75% had not signed DORA (Gaind, 2018). The survey also found that while 52 institutions had implemented some measures to promote the responsible use of metrics, only four had taken what the Forum for Responsible Research Metrics[34] considers "comprehensive action".

While discouraging the use of JIF, the UK is making efforts to ensure metrics generally are used responsibly. Following the 2014 REF results, the Higher Education Funding Council for England (now Research England) commissioned an independent review of the role of metrics in research assessment and management (Wilsdon et al., 2017). They found that the REF evaluation gave different outcomes than individual research metrics and that the research community remained sceptical regarding the use of metrics. The report contained 20 recommendations, which led to the formation of the UK Forum for Responsible Research Metrics[35]. These efforts aim to encourage metrics that align with good research practices. It

[33] https://www.ref.ac.uk/guidance/
[34] https://www.universitiesuk.ac.uk/policy-and-analysis/research-policy/open-science/Pages/forum-for-responsible-research-metrics.aspx
[35] https://www.universitiesuk.ac.uk/policy-and-analysis/research-policy/open-science/Pages/forum-for-responsible-research-metrics.aspx

remains largely unclear, however, to what extent researchers are aware of these initiatives and whether they steer research practices and research integrity.

3.4 Grant funding

Individual researchers and research groups may also receive funding from UK organisations such as UKRI Research Councils, NIHR, Wellcome and other charities. These organisations set their own conditions for funding to incentivise best research practices. The UKRI Research Councils have policies, binding on recipients of their funding, that set out standards for research integrity. These policies cover requirements both for ensuring good research practice and for the investigation and reporting of allegations of research misconduct.

The UKRI Research Councils include questions on research integrity within their Funding Assurance Programme, publishing annual statements of misconduct allegations that come to their attention[36]. They also take research integrity and research culture into account in their strategic priorities[37]. The Medical Research Council (MRC) now allows the inclusion of a reproducibility and statistical design annex, and has guidance that grants that do not provide an adequate sample size justification should be scored as un-fundable (Medical Research Council, 2016). However, the level of enforcement is unclear and funding decisions depend on peer-review panels, which may bring with them disciplinary and institutional norms and biases. In addition, regulations that serve as a prerequisite to receiving funding (such as requiring a data-sharing plan in the funding application) are often easier to enforce than practices that are mandated after receiving funding (such as complying with data-sharing plans). For example, Wellcome's data, software and materials management and sharing policy[38] takes a broad approach to outputs management to ensure maximum openness and accessibility. Applicants are required to provide output management plans and make underpinning data, code and so on accessible on publication.

3.5 Industry sponsorship

Other national level organisations, including industry and non-governmental organisations, may influence researcher behaviour in several ways. Increasingly, academic research is conducted in collaboration with, and partially or fully funded by, other organisations, particularly industry. These academic-industry partnerships are recognised as important for knowledge exchange, innovation and long-term economic growth. Industry, understandably, provides research funding for projects related to its own interests. However, this may influence the questions researchers ask, which may then impact on the design, conduct and interpretation of those studies by academic researchers. There is evidence that industry-sponsored medical and nutrition research is 3.6 times and 7.6 times, respectively, more likely to contain pro-industry conclusions than comparable non-industry sponsored research, suggesting that industry funding may bias researchers, consciously or not (Bekelman & Gross, 2003; Lesser, Ebbeling, Goozner, Wypij & Ludwig, 2007). The differing rates of positive results suggest that researchers may be engaging in questionable research practices (such as selective reporting) because they are incentivised to find positive results to satisfy their industry sponsors. Conversely, it is worth noting that in biomedical research it was the pharmaceutical industry that led the way in highlighting the low quality and lack of replicability of much published academic research (Prinz, Schlange & Asadullah, 2011).

[36] https://www.ukri.org/about-us/policies-and-standards/research-integrity/
[37] https://www.ukri.org/about-us/strategic-prospectus/foundations-for-excellent-research-and-innovation/
[38] https://wellcome.ac.uk/funding/guidance/data-software-materials-management-and-sharing-policy

Moreover, commercially sponsored clinical trials are much more likely to post their results than non-commercially sponsored trials (68% versus 11%, Goldacre et al., 2018).

3.6 Independent organisations and networks

In the UK, a group of researchers recently created a peer-led consortium, UKRN[39] to promote robust research and best research practices. UKRN currently includes local networks within 43 universities throughout the UK and works alongside funders, publishers and other stakeholders. A focus of UKRN is the coordination of activity across stakeholders, to ensure their efforts to shape incentives in a way that promotes research integrity are aligned. UKRN also aims to ensure that researchers (and in particular early-career researchers) have a voice in this debate, so that their perspective on the impact of incentives on their behaviour is recognised and incorporated by stakeholders, and initiatives by stakeholders can be reviewed and evaluated by researchers who will be affected by them.

Organisations such as UKRIO[40] and Nuffield Council[41] provide a perspective from outside academia, with the aim of improving research culture. The Nuffield Report on the Culture of Scientific Research in the UK (Nuffield Council on Bioethics, 2014) explored the consequences for research integrity of the scientific research culture in encouraging good practice and producing high-quality research.

UKRIO[42] is an independent charity offering support to the public, researchers and organisations to further good practice in academic, scientific and medical research. It pursues those aims through publications on research practice, the support and services it provides to research organisations, education and training activities, and by providing expert guidance in response to requests for assistance, drawing on a register of advisors. UKRIO have seen a steady increase in the number of requests for assistance, the majority of which come from UK institutions (UKRIO, 2018). This trend may be due to a number of factors: increased awareness of the importance of research integrity, increased awareness of UKRIO, and proactive and reactive enquiries.

3.7 Learned societies and professional bodies

Learned societies usually operate at the UK level and can also act as funders, publishers and accrediting organisations, among other activities. They have a similar sphere of influence to professional bodies and at times may overlap with them. For example, the British Psychological Society offers chartered status to psychologists, publishes a scholarly journal and provides modest funding; in other words, a single body is responsible for both academic and professional aspects of psychology. In contrast, the British Medical Association (BMA) publishes the British Medical Journal but the General Medical Council (GMC) accredits medical doctors: academic and professional aspects are divided between the organisations.

These types of organisation offer the potential for internal discipline-specific regulation at the national level, although this may be more complex where responsibility is shared across multiple organisations (as with the BMA and GMC). In their position as publishers and accrediting organisations they hold power to shape research practices. However, while

[39] https://www.bristol.ac.uk/psychology/research/ukrn/
[40] https://ukrio.org/
[41] http://nuffieldbioethics.org/
[42] https://ukrio.org/

professions such as medicine and law require accreditation and evidence of continuing professional development, academic researchers are not accredited in a similar way: the only qualification is a PhD or other educational attainment, with no requirement for ongoing training. The Science Council introduced professional registration for scientists (Registered Scientists, RSci)[43] in 2012 and some organisations (such as the Defence Science and Technology Laboratory) have begun to encourage this among their staff, but uptake remains relatively limited, certainly within institutions.

3.8 Recent trends

More attention has been paid recently to the research culture in the UK, with the Royal Society, Wellcome, and UUK all having focused attention on this in recent years, including issues that impact on research integrity (see Table 1 and the list of Wellcome policies[44]). The Department for Business Innovation and Skills commissioned research into improving the funding practice of the Research Councils (Nurse, 2015) and the Science and Technology Committee recently conducted an inquiry into research integrity. This focused on "trends and developments in fraud, misconduct and mistakes in research and the publication of research results" (Science and Technology Committee, 2018). One outcome of this inquiry was the move to establish a national research integrity committee, with a particular focus on research misconduct, hosted by UKRI[45]. These reports do not mandate particular research practices, but they demonstrate the involvement of government and policymakers in the conversation with institutions, disciplines and individual researchers regarding how to improve research integrity.

3.9 Regulation

Government inquiries and Acts of Parliament can also set frameworks for good research integrity. The Human Fertilisation and Embryology Acts of 1990 and 2008 established a governmental organisation to monitor and licence fertility clinics as well as to demarcate the boundaries for what constitutes "necessary and desirable" research (Parliament of the United Kingdom, 1990). There is, however, some resistance from the academic research sector against external regulation relating to research integrity. In the Science and Technology Committee commissioned report, the Russell Group of research-intensive universities and UUK argued that employing regulatory bodies to oversee compliance may foster a culture of compliance that encourages sufficient behaviour but disincentivises researchers and institutions from striving for excellence (House of Commons Science and Technology Committee, 2018). However, there is no evidence for or against this statement.

3.10 Impact on researcher behaviours

The mechanisms and extent to which these high-level initiatives have downstream influence on individual behaviours related to research integrity remains unclear. For example, how overarching national initiatives such as the Concordat to Support Research Integrity influence individual researchers remains unclear because cause and effect are difficult to establish and may be disconnected or delayed. The Concordat is more likely to inform institutional policies, which are then felt downstream by researchers, who may not know the original source of the influence (UUK, 2016). Data from the UK Careers in Research Online

[43] https://sciencecouncil.org/scientists-science-technicians/which-professional-award-is-right-for-me/rsci/
[44] https://wellcome.ac.uk/funding/guidance/policy-and-position-statements
[45] https://www.parliament.uk/documents/commons-committees/science-technology/Correspondence/190625-Letter-to-Chair-from-Chris-Skidmore-on-Research-Integrity.pdf

Survey (CROS) reveals that 67% of research staff respondents had not heard of the Concordat, while 24% knew of its existence and only 9% had some understanding of its content (Vitae, 2017). Measures of how commonly the Concordat is referenced in institutional and departmental policies, and how it is encouraged or enforced at these levels, may provide a better understanding of its influence than reports from individual researchers.

Individual researchers are influenced directly by some national initiatives. At the national level, research funder, and publisher, policies appear to lead to better research practices, although levels of enforcement vary widely and few studies have measured levels of compliance. Securing funding and publishing papers are essential academic tasks; as a result, mandating research practices before receiving funding or publishing can serve as a strong motivator for individual researchers.

However, the extent and direction of influence are not always as expected and are open to unintended consequences. For example, the REF attempts to counter the use of JIF as a measure of quality, instructing evaluators not to use this. But many researchers do not believe that evaluators follow this instruction and consequently believe that the REF incentivises publishing in high-JIF journals (Nuffield Council on Bioethics, 2014).

Table 1: Overview of UK reports on research integrity.
In the UK, a range of reports have discussed research integrity in the past few years. Surveys and guidelines have been developed through the collaboration of government agencies, independent research organisations and individual researchers.

Title and reference	Commissioner or author	Summary
Concordat to Support Research Integrity (Hale et al., 2012) Revision October 2019	UUK	This document provides a national framework for good research conduct and its governance and is open to signatories.
The Culture of Scientific Research in the UK (Nuffield Council on Bioethics, 2014)	Nuffield Council on Bioethics	This report summarises the results of an investigation into UK research culture, which comprised an online survey of researchers, discussion events held at universities and evidence-gathering meetings with funding bodies, publishers, editors and academics.
Ensuring a Successful UK Research Endeavour - A Review of the UK Research Councils (Nurse, 2015)	Department for Business, Innovation & Skills (commissioned)	This independent review of the UK Research Councils included a call for evidence and provided recommendation on how the UK Research Councils should support research.
The Concordat to Support Research Integrity: A Progress Report (UUK, 2016)	UUK	This report is a review of the implementation of the Concordat to Support Research Integrity.
The Metric Tide: Independent Review of the Role of Metrics in Research Assessment and Management (Wilsdon et al., 2017)	Minister for Universities and Science (commissioned), Higher Education Funding Council for England (funded)	This review focuses on research metrics in the UK and how they relate to REF 2014 evaluations, and provides recommendations for stakeholders in the UK research ecosystem.
Research Culture: Changing Expectations Conference report (The Royal Society, 2018b)	The Royal Society	This report comes from a conference that promoted discussion on how to foster a healthy research culture as part of a wider project on the research culture.
Integrity in Practice Toolkit (The Royal Society and the UKRIO, 2018)	The Royal Society and UKRIO	This toolkit outlines several case studies of how researchers can promote research integrity in their group.

Title and reference	Commissioner or author	Summary
Research Integrity - Sixth Report of Session 2017-19 and Response from Government and UKRI (Seventh Special Report of Session 2017-19) (House of Commons Science and Technology Committee, 2018)	Science and Technology Committee (appointed by the House of Commons)	This government inquiry into research integrity included over 100 written submissions, six oral evidence sessions and responses from the government and UKRI.
Research Integrity: Clinical Trials Transparency – Tenth Report of Session 2017-19 and Response from Health Research Authority (Tenth Special Report of Session 2017-19) (Science and Technology Commission, 2018)	Science and Technology Committee (appointed by the House of Commons)	This government inquiry focused on research integrity in clinical trials and included written submissions, oral evidence sessions and a response from the Health Research Authority.
International Landscape Study of Research and Innovation Systems (Techopolis, 2019)	Research England (commissioned)	This report compared national research funding mechanisms in 20 research-active countries.

4 Institutional level

Many of the key factors that drive the behaviour of researchers, including hiring and promotion criteria, operate at the institutional level. Hiring and promotion evaluations often rely on factors such as publications and grant income, often with a focus on metrics (such as JIF and grant award value) rather than more qualitative measures of good research practice (McKiernan et al., 2019). Evaluation committees also consider other metrics such as h-indices, number of publications and citation counts. These metrics capture some elements of a researcher's contribution but can overlook other aspects including quality and rigour, and an emphasis on metrics may lead researchers to 'game' the metric.

As highlighted earlier, prestige is often associated with publishing in journals with a high-JIF. Emphasis on 'impact' more broadly (in other words research that might contribute to a REF impact case study) can exert a positive influence by aligning the work of researchers with public interest. However, this emphasis may also incentivise researchers to prioritise work likely to have impact in the short term over more speculative work that might not generate tangible impact for some years.

4.1 Performance management

Academic institutions can also shape local research culture by how they manage and measure the performance of their researchers. Institutions tend to measure research performance using criteria similar to those used in hiring practices. These measures can include targets for the quality and quantity of research outputs and grant income, as well as more qualitative reports from line managers and heads of departments. Institutions may encourage high performance on these measures through mandates, financial incentives, or prizes to researchers and their departments. In the absence of alternative incentives, institutional emphasis on research performance indicators can drive behaviours that maximise output quantity and media coverage, with less concern for quality (Fire & Guestrin, 2019). Where there is an emphasis on quality, it is often via a proxy such as JIF. In contrast, the REF attempts to incentivise quality by requiring a small number of high-quality submissions. Whereas REF evaluations are infrequent and their methodology can change substantially, routine institutional behaviour (such as hiring and promotion) may remain more consistent; both are important drivers of researcher behaviour. It remains unclear to what extent the tension between these different evaluation systems drives the practices of individual researchers.

Institutions may also indirectly evaluate researchers on how many doctoral researchers they supervise. Particularly in the sciences, more doctoral researchers can translate to more research output. However, some evidence suggests that research quality may decrease if a researcher focuses strongly on increasing their supervisee count (Carayol & Matt, 2006).

Probationary periods are another example of performance management procedures that can incentivise particular research practices. Academic researchers will often be subject to probationary periods ranging from several months to several years. During this period, they are expected, explicitly or implicitly, to reach some set of measurable goals as a condition of maintaining their post (for example number of publications in certain outlets, predetermined amount of grant income). Researchers who fail to achieve these during their probationary period may lose their jobs. As a result, these probationary requirements act as strong and salient incentives that can shape research activity and exclude researchers who do not

perform well against these indicators. To perform well against a number of these indicators (such as publishing), researchers may engage in questionable research practices (John, Loewenstein & Prelec, 2012).

4.2 Professional development and training

Beyond performance evaluation, institutional policies can encourage higher levels of research integrity by encouraging investment in professional development activities. For example, institutions may require or encourage line managers to offer early-career researchers a certain number of working days per year towards training. They may also offer grants, subsidies or other material support in pursuit of training, either more generally or within areas that the institution particularly values. A common model assumes that supervisors will instruct their researchers in research integrity, but in many cases the supervisors are not trained themselves and may not feel recognised for doing so: 28% of academics strongly agreed that they are recognised and valued for their contributions to good research conduct, similar to academic collaborations (24%), but significantly lower than for research outputs (45%) and securing funding (50%) (Vitae, 2017). The same report reveals that only 35% of research staff respondents have had training in ethical research conduct, while 28% would like to do so; 37% have no interest in this. A recent trend is to have researchers complete online modules on research integrity[46]. It may remain difficult, however, for researchers to transfer what they learn through courses to everyday practices if the framework and incentives for good practice are absent, particularly at the department or research group level. The impact of research integrity training on researcher behaviour is not yet well established (Steneck, 2013).

4.3 Bullying and harassment

There are concerns about the level and tolerance of bullying and harassment: various US surveys suggest that 25-35% of academics have been bullied in the workplace in the past year, compared to 10-14% of the general population[47]. A 2018 report revealed that nearly 300 UK academics were accused of bullying students and colleagues[48]. Academic bullying may pressure researchers explicitly or implicitly to falsify data or engage in questionable research practices. Universities have mixed incentives for how to address academic bullying. While many universities do attempt to actively and robustly tackle bullying, some have attempted to cover up instances of bullying that have occurred[49]. Many national-level funders now also have bullying and harassment policies (such as Wellcome[50], UKRI[51]). To fully address the care, respect and accountability criteria of research integrity, as defined in the Concordat, institutions would need to address academic bullying and harassment more concretely.

4.4 Institution type and culture

When considering incentives and research integrity at the institutional level, it can be helpful to acknowledge the differences between research-intensive and less research-intensive

[46] https://www.epigeum.com/courses/research/research-integrity/
[47] http://comm.wayne.edu/files/keashly_spectra2015.pdf
[48] https://www.theguardian.com/education/2018/sep/28/academics-uk-universities-accused-bullying-students-colleagues
[49] https://www.bbc.co.uk/news/education-47936662
[50] https://wellcome.ac.uk/funding/guidance/bullying-and-harassment-policy
[51] https://www.ukri.org/files/termsconditions/rcukukriterms/harassment-amp-bullying-pdf/

institutions. Academic researchers at Russell Group universities and other research-focused institutions may be under considerable pressure to obtain grant funding, which can entail spending more time writing grant applications and therefore, perversely, less time proportionally conducting research. One study showed that Australian researchers spend 550 person-working years' worth of effort each year on writing grant applications to their National Health and Medical Research Council (Herbert, Barnett, Clarke & Graves, 2013). Since less than a quarter of applications are accepted, this amounts to substantial waste in the research ecosystem. The time spent may differ in the UK, but the overarching principle remains. When surveyed, researchers also reported tailoring their work in order to meet strategic funding calls (Nuffield Council on Bioethics, 2014). Teaching-focused institutions, in contrast, may have less-developed procedures for research oversight and their researchers receive less support and training in research practice and grant applications, as well as less scrutiny of the research they do. This combination of factors suggests that the system of research incentives at teaching-focused institutions could be more variable than at research-focused institutions, but there is no evidence of whether this is necessarily better or worse in terms of their impact on research integrity.

The research culture particular to each institution can also impact on research practices. Institutions with relatively competitive cultures may incentivise researcher behaviours in a way that focuses on visibly rewarded outcomes (for example, publication in high-JIF journals) rather than less visible but important processes such as rigour of research methodology and documentation, or fostering of good practices in colleagues and doctoral researchers. Incentives can in principle be advantageous if research integrity is explicitly rewarded. However, only a culture that promotes intrinsic motivation for research integrity can encourage the less visible processes. Similarly, the perceived prestige of an institution may place pressure on researchers to live up to its reputation and in turn produce ostensibly prestigious research outputs. For instance, there is observational evidence that in five of the UK institutions considered most prestigious in preclinical rodent research according to the last REF, reporting of measures to reduce bias (such as randomisation, blinding and sample size calculation, which are widely considered best practice) was if anything lower than average, compared with a random sample of research in the field (that is, a study drawn at random from relevant studies in PubMed) (Macleod et al., 2015).

4.5 Research ethics

As recommended in the Concordat to Support Research Integrity, most research institutions have formal ethics and integrity policies and processes. Institutions generally have research ethics committees that set formal regulations and requirements on research projects to ensure they are ethically sound and also protect research subjects, both human and animal. Research ethics committees can provide formal incentives in terms of mandates and requirements; for instance, before approving research to go ahead. Committees typically require researchers to demonstrate their planned research complies with laws protecting human participants' personal data and treats animals used in experiments in the most humane ways possible within their research programmes. Research integrity officers provide advice, promote best practice and may administer formal research integrity training within institutions. However, levels of enforcement of good practice may vary among institutions. There is anecdotal evidence of institutions not signing up to the research integrity Concordat as institutions are expected to report on misconduct allegations, which could result in adverse publicity for them.

4.6 Impact on researcher behaviours

Taken together, as set out in the Concordat to Support Research Integrity, institutions have considerable responsibility to maintain an environment that is conducive to rigorous and high-quality research. Institutional policies and practices vary in how explicit they are about the importance of research integrity and in setting the expectations and tone for how research is conducted. This duty includes consideration for how an institution evaluates potential hires and current staff, handles research integrity issues, provides training in research integrity and incentivises a healthy research culture.

5 Disciplines

The nature of research outputs differs among academic disciplines. Whereas the sciences tend to prioritise collaborative peer-reviewed journal publications, the arts and humanities, and to some extent the social sciences, encourage single-author monographs and books. Preferences for certain types of output may incentivise certain research practices and disincentivise others. For example, in a field where journal publications are the norm, researchers who want to increase their number of outputs and number of times their work is cited may opt to publish shorter manuscripts - known more colloquially as the 'least publishable unit' or 'salami slicing'. This practice will be less incentivised in fields that encourage monographs and books.

5.1 Research outputs

Similarly, multi-authored publications encourage collaboration, but may also encourage 'guest' authorships where authorship is granted to individuals who make negligible contributions to the work (Wislar, Flanagin, Fontanarosa & DeAngelis, 2011). There is also evidence that the prestige associated with individuals and institutions may increase the chances of publication (Peters & Ceci, 1982). Other factors related to other elements of the research ecosystem may also operate in perhaps unintended ways. Most journals have limits on word count and display items (such as tables and figures) which may force authors to not fully report their methodology or results and, therefore, may make their research more difficult to understand or reproduce. This may vary considerably across fields, and where these limits differ, creating further complexity in the case of multidisciplinary research where the norms of the contributing disciplines may be very different.

Outputs that have traditionally not been a priority, such as datasets, tools, public outreach, knowledge transfer, early career researcher training and open research practices, are beginning to be incentivised in certain disciplines (such as open access brain imaging repositories; Gorgolewski et al., 2015; Niso et al., 2016) and by certain organisations (such as the Open Science Career Assessment Matrix from the European Commission), but again this is variable across disciplines. It is worth noting that the literature on research integrity is much more extensive for science, technology, engineering, and mathematics fields (STEM) and, in particular, biomedical sciences, than for the arts and humanities.

Disciplines also differ in how they evaluate research outputs, either implicitly or explicitly. For example, in the sciences researchers are often implicitly ranked based on quantitative metrics such as the number of papers published and the number of citations these papers have received. These metrics are featured prominently on academic websites including Scopus, Google Scholar and ResearchGate and can be used to predict which researchers will become principal investigators (Van Dijk et al., 2014). However, some fields receive

much higher citation rates than others (such as molecular biology versus social sciences; Times Higher Education, 2011). It is therefore difficult to compare researchers between disciplines using these metrics (Fire & Guestrin, 2019). The differences between fields in terms of JIF and author-level citation rates stem from variations in the number of researchers in a discipline, the volume of citations per article, the length of publications and differing citation practices.

These issues have led to the development of other metrics such as field-weighted citation impact, which provides a metric that is designed to be comparable across disciplines. Field-weighted citation impact improves upon JIF and is beginning to be used to evaluate researchers (for example, Techopolis, 2019). Some organisations have also attempted to metricise researcher contributions (for example, ResearchGate 'score' and academia.edu 'author rank'); however, these 'black box' calculations are rarely used. Other fields may focus more on quality rather than quantity, or on other measures of impact with fuzzier boundaries that cannot be easily be captured in a bibliometric analysis.

5.2 Prestige

Regardless of the discipline, research practices will tend to be skewed towards producing the type of output that awards credit, prestige and, in turn, funding and career advancement. An analysis of over 120 million papers demonstrates that longer author lists, shorter papers, rising publication numbers, self-citations and lengthy reference list have compromised the usefulness of many bibliometrics to measure the value of a researcher's work (Fire & Guestrin, 2019). The trajectory of publishing practices appears to follow Goodhart's Law, which states that "when a measure becomes a target, it ceases to be a good measure". The Leiden Manifesto acknowledges this and advocates regularly updating research evaluation criteria.

Within some disciplines there are initiatives that attempt to align what is good for a researcher's career with what is best for the progress of research itself (for example Registered Reports: Chambers, 2013). The Registered Reports model, which peer-reviews the research question and methodology prior to data collection, appears to increase the number of published null results from around 4% (Chavalarias et al., 2016) to about 60% (Allen & Mehler, 2019). This rate of null results is broadly consistent with that from clinical trial research, which has a longer history of regulation and pre-registration. The Registered Reports model removes the incentive to focus on results as part of the publication process, which may influence author, reviewer and editor decision-making (as discussed previously in Section 2). These efforts are not yet mainstream and it remains unclear how some of them will transfer to all disciplines.

5.3 Authorship and recognition of contribution

Disciplines vary in the way they assign credit for research outputs. For articles with multiple authors, researchers often view the first author as the major contributor and the last author as the mentor, and assign little credit to middle authors (for example, in medical publishing: Zbar & Frank, 2011). However, high-energy physics lists authors alphabetically, includes engineers as well as researchers, and may include hundreds and in some cases thousands of authors. Economics also lists authors alphabetically. In both these disciplines the contribution of each author is not discernible. In the life sciences, the first author is expected to have conducted the majority of the work and the last author is often assumed to be the senior team member who oversaw the project. In genetics, there are often multiple authors

ranked as first, second and senior. Science research has become a team exercise where current authorship models cannot properly attribute credit to each contributor (Holcombe, 2019). For example, the International Committee of Medical Journal Editors currently states that all authors must contribute to the writing of a manuscript and be accountable for all aspects of the work[52]. This means that contributors, who collected data, designed the experiment and performed statistical analysis and other measures, but do not write, may receive no credit for their work.

These norms may encourage shallow collaboration to earn middle authorships, but discourage highly involved collaborations due to lack of substantial recognition. This practice can weigh on research integrity by incentivising researchers to take actions to maximise their perceived output rather than what may be more valuable research output. Novel models for assigning credit for contributions to publications, such as the Contributor Roles Taxonomy (CRediT) framework[53], encourage accurate documentation that provides incentives to contribute to all elements of a research work. With contributorship models such as CRediT, researchers are more accountable for the aspects of the work they performed. In contrast to many of the current authorship models, where it is difficult to know who conducted the analysis as opposed to who wrote an initial draft of a paper, CRediT more clearly outlines the roles of each contributor.

5.4 Conflicts of interest

In some disciplines, authors also increasingly report whether or not they have a conflict of interest. It is important to note that conflict of interest statements identify whether there is or is not a potential conflict of interest; they do not imply that a genuine conflict exists, or that the research has been directly influenced. In 2000, only 5.6% of biomedical papers included a conflict of interest statement (Iqbal, Wallach, Khoury, Schully & John, 2016); in 2015-2017, 65% did (Wallach et al., 2018). Conversely, in the social sciences, only about 18% of papers currently include a conflict of interest statement (Hardwicke, Wallach, Kidwell & Ioannidis, 2019). As a result, in the vast majority of social science publications, the reader is simply unaware of whether or not the authors have a potential conflict of interest. For example, speaking fees may present a conflict of interest. Some researchers may tailor their work to increase the attractiveness of their presentations and receive thousands or tens of thousands of dollars to speak at an event, which many researchers do not perceive as a conflict of interest (Chivers, 2019). Non-financial conflicts of interest also exist and include political, personal, religious, ideological, academic and intellectual competing interests[54]. Research integrity involves transparency and openness, which includes proper disclosure of such interests.

5.5 Grant funding

Funding mechanisms also differ to some extent across disciplines, reflecting different UKRI Research Councils' requirements as well as those of other organisations (such as the Royal Society, the British Academy, Wellcome and various other charities). Funder guidelines and processes will therefore shape researcher behaviour in a way that may impact on research integrity (see Section 3 for a description of how the MRC policy incentivises well-designed

[52] http://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html
[53] https://www.casrai.org/credit.html
[54] https://www.biomedcentral.com/getpublished/writing-resources/competing-interests

experiments). Critically, these funders will also typically draw on researchers to review grants and sit on grant awarding panels and boards. Independent reviews of funding applications often do not align with each other, suggesting that chance plays a role in funding decisions (Graves, Barnett & Clarke, 2011).

5.6 Large-scale collaborations

Each field fosters a set of behaviours, values and norms that come together to shape discipline-specific research cultures. Large-scale collaborations have become the norm in disciplines such as genetics and particle physics due to the size of the datasets and infrastructure needed for relevant projects (for example, the UK Biobank, the Large Hadron Collider). Other disciplines remain more individualistic, which may lead to inefficiency if multiple teams or individuals work on very similar projects without communicating (for example, in meta-analysis in medicine: Siontis & Ioannidis, 2018).

When collaboration is low, researchers across many fields may fear being 'scooped' (that is others will publish their research idea first, rendering their own research less original or impactful). Fears of scooping can inhibit practices such as sharing data or ideas and may cause researchers to cut corners in a race to publish first[55]. To counteract this practice, the journal PLOS Biology has recently introduced a policy of considering publications for up to six months after a report on a similar research question has been published elsewhere (the PLOS Biology Staff, 2018). This policy may remove the fear of being scooped, which some people have argued is an unwarranted fear in the first place[56] (Schwarzkopf, 2016). Without a fear of being scooped, researchers may be more open and transparent about their research. They may also be more rigorous because they have less of an incentive to be the first to publish on a topic. These initiatives to deal with behaviours around scooping are relatively new and data have yet to be collected regarding their impact.

5.7 Pre-prints

Another norm in some fields such as mathematics and sub-disciplines of physics is uploading preprints to open access repositories, or the use of working papers (for example, as in economics). This allows new knowledge to be disseminated more rapidly, assigns priority to the study authors and allows for earlier, more extensive peer-review by the wider community. The average academic journal will publish a manuscript 125 days after it is submitted (Powell, 2016), but publication can take much longer if a manuscript is rejected by multiple journals before it is eventually published. Researchers may be incentivised to upload preprints to gain timely feedback from peers, to receive more immediate credit for the work they have done, to make it available for other researchers to build on, or because preprints are a norm within their discipline. Published articles that have an associated preprint are more highly cited (at least in biology) than comparable articles with no preprint (Fraser, Momeni, Mayr & Peters, 2019). Researchers in many disciplines do not yet routinely upload preprints, and although this practice is growing, it has yet to become embedded universally. It remains much more common in specific disciplines (such as physics) and sub-disciplines (such as genomics, within the biomedical sciences) where the practice of data sharing is also much more established.

[55] https://blogs.lse.ac.uk/impactofsocialsciences/2015/12/16/whos-afraid-of-open-data-dorothy-bishop/
[56] https://blogs.lse.ac.uk/impactofsocialsciences/2016/04/19/so-youve-been-scooped/

5.8 Learned societies and professional bodies

Many disciplines have dedicated professional societies that are generally orientated towards practice rather than research. These societies nonetheless have the capacity to set codes of conduct and mould the norms and expectations that can drive positive research behaviours. In other words, they can shape the research culture of their discipline. Researchers who also practice a speciality will often be part of a professional society (for example, psychologists, medical doctors and lawyers). These societies can sanction inappropriate behaviours and provide a code of conduct.

The GMC revoking the licence of Andrew Wakefield, the proponent of the vaccine-autism myth, when they discovered he falsified data is an example of the benefit professional societies can exert on research integrity. In contrast, when a consumer behaviour researcher, Brian Wansink, was found guilty of scientific fraud, his institution reprimanded him but there existed no professional society to revoke a licence or enact other sanctions. Nevertheless, some research disciplines without dedicated professional societies have still set out guidelines for research conduct, for example the Concordat on Openness on Animal Research in the UK. A professional body's right to revoke a licence will likely inhibit future research misconduct by the reprimanded researcher; however, it remains unclear whether the ability to revoke a licence serves solely as a treatment of misconduct, or whether it also serves as a preventative measure by disincentivising misconduct.

5.9 Impact on researcher behaviours

To further illustrate how the norms of a discipline can drive researcher behaviour, the clinical trials field provides an informative case study. To combat selective reporting and publication bias, several funders and journals now mandate pre-registration of clinical trials. Many medical journals now only accept trials that have been pre-registered. National and supranational registries such as the ISRCTN (originally the International Standard Randomised Controlled Trial Number)[57], the EU Clinical Trial Register (EUCTR)[58] and the US ClinicalTrials.gov[59] now hold over 18,000, 35,000 and 312,000 registered studies, respectively. There is some evidence that this has led to a reduction in the publication of positive results, suggesting that the true ratio of positive, neutral (or null) and negative results is very different to the ratio among published studies (Kaplan & Irvin, 2015). However, although pre-registration is now widespread, the proper reporting of pre-registered outcomes is not incentivised and is therefore less well adhered to.

A recent study demonstrated that most clinical trial publications had removed or added outcomes without proper disclosure (Goldacre et al., 2019). In this context, researchers are incentivised to pre-register their study because it is a norm in their research culture and a necessary step to receive approval from many journals, funders and peers. If clinical trial researchers do not pre-register it will be more difficult for them to publish their findings, receive funding in the future and attain prestige. Whether a study is pre-registered is stated conspicuously in published manuscripts and is easy to verify. Properly reporting pre-registered outcomes, however, is less incentivised. It takes time to verify whether outcomes are properly reported and only about one third of peer reviewers ever look at pre-registration documents (Mathieu, Chan & Ravaud, 2013). There are also no clear repercussions for

[57] http://www.isrctn.com/
[58] https://www.clinicaltrialsregister.eu/
[59] https://clinicaltrials.gov/

incorrect reporting of pre-registered plans, with no reported incidences. In clinical trial research, pre-registration has been incentivised highly enough to make it a norm for the discipline. However, care has not yet been taken to ensure that pre-registering is serving its desired purpose of increasing the transparency of exploratory versus confirmatory research. This example suggests that steps can be taken to improve research integrity, but they must be enforced at every stage in the research process to maximise positive impact.

Overall, disciplines are in positions to strongly influence research integrity by fostering a research culture that promotes best practice. Compared to a decade ago, many more research articles contain a conflict of interest statement and funding statement, likely in part due to publishing requirements of disciplinary journals. Journals in specific disciplines have also created incentives for research practices such as pre-registration and data sharing. In this sense, disciplines hold influence over research practices by requiring certain elements before publication. However, disciplines currently exert less influence in terms of calling out and penalising poor behaviour.

6 Departmental level

Departmental factors shaping research integrity will often be closely related to institutional factors. However, while many departmental factors are directly shaped by institutional practices or guidelines, they will tend to be more idiosyncratic based on the differing needs of individual departments and on the personalities and management styles of people in senior departmental positions. For instance, institutions may enact guidelines for hiring and promotion criteria, but it will be departmental search committees and line managers who interpret these criteria to inform their actual decisions. Similarly, an institution or division may set research income targets for departments, but the department then retains the power to distribute those income targets across individuals according to their own criteria. Departments may also reflect disciplinary cultures, and even sub-cultures within disciplines, leading to the potential for methodological and disciplinary silos. This, in turn, can shape what methodologies are favoured, what undergraduates, postgraduates and other early-career researchers learn and how research integrity standards are promulgated through research groups.

Departments often have direct gatekeeping powers over which funding applications they will allow their researchers to submit. This power to approve or deny a funding application is usually vested in a select cohort of senior figures. For example, UK grant applications may or may not include overheads, and in many departments grant applications that will not bring in overheads can only go ahead with the approval of the head of department. A policy at the departmental level may therefore shape researcher behaviour towards certain types of funder. Accordingly, the decisions of a few senior figures may disproportionately influence the type of research done by all researchers in a department. This pressure may affect early career researchers most, as they are more likely to be on fixed-term contracts or time-limited funding, have little leverage in the department and generally have more uncertainty about their career prospects. It can be especially acute considering that there is some evidence that early career researchers are less likely to win grants compared to older researchers (Maher & Sureda Anfres, 2016).

Academics, especially those later in their careers, are usually required to balance departmental-level leadership or management responsibilities alongside their research roles

[60]). Departments may assign considerable teaching duties and administrative loads to academics, whilst evaluating them primarily on research output (Cadez, Dimovski & Groff, 2017). In the Royal Society's meeting on research culture, one of the questions to the panellists that was most voted for by attendees was "…every academic job component is growing: teaching, research, policy etc. and it's a lie that it's possible to do more of everything" (the Royal Society, 2018b). The resulting time pressure may encourage researchers to choose between the aspects of research integrity that come with a time-cost and their other duties that are more directly rewarded. For example, if training in data-sharing practices is not incentivised (for example, by inclusion in promotion criteria) it may be assigned a low priority.

Overall, departmental factors related to research integrity will often be more directly relevant to researchers than institutional forces, because they are closer to them: those enforcing and demonstrating research practices at a departmental level are generally colleagues and direct supervisors. For instance, if a researcher's peers and colleagues within the same department, or research group, concretely demonstrate norms of research practice that are in conflict with the guidelines of the researcher's institution, social norms will strongly influence the researcher to follow their colleagues instead of the guidelines. The hierarchical structure of departments reinforces this pattern. For example, whereas institutional guidelines for probationary periods may stipulate that the choice of publishing outlets should not affect assessment of research quality, a researcher may well know that their direct line manager in reality expects them to publish in particular (high-JIF) journals that may not necessarily be the most appropriate venue for their work.

Given the immediacy of the environment, 'departments' or research group, this may serve as the level where research culture is most tangible. One might expect a salient effect due to the social cohesion needed to maintain an everyday work environment, and to the potential impact on career prospects. The US Survey of Organisational Research Climate (SOuRCe) identified a direct relationship between positive perceptions of the research climate and higher likelihoods of positive research practice and lower likelihoods of undesirable, research practices (Crain et al., 2013; Wells et al., 2014). However, more research is needed on how the culture of a department influences individual researcher behaviours, as well as evaluation of the differences between individual departments within or between universities to shed light on the strength of departmental influences.

7 Individual level

Overall, the academic environment and employment market is highly competitive. There are fewer academic research positions than people who would like to fill them (Maher & Sureda Anfres, 2016). The researchers who successfully remain or advance in academia are not a random selection. Those who perform well according to the assessment measures of other researchers, publishers, funders and hiring committees end up forming the body of academic researchers. If these assessment measures accurately reflect what is good for research as a whole, then they can promote individual behaviours that contribute to research integrity. When the incentives are poorly aligned, however, they may inadvertently select for poor research practices. For example, for decades there have been calls to increase the statistical power of scientific experiments (in other words running larger studies), alongside efforts to correct misunderstanding in this domain (Button, 2016; Button et al., 2013). However, low statistical power (for example, studies that are too small to detect likely effect

[60] Example professor role profile http://www.bristol.ac.uk/hr/grading/academic/role-profiles/2e.html

sizes) can enable an increased number of research outputs for a given level of resource, even if the results of these studies are less reliable (Smaldino & McElreath, 2016). As a result, in the current incentive structure implicitly based on volume of publications, poor statistical practices are rewarded. Researchers can advance their career and pass on 'questionable' research practices to their supervisees, who will themselves produce a high level of non-rigorous output and move on to create the next generation of researchers (Smaldino & McElreath, 2016).

Discussions on research integrity often overemphasise deliberate misconduct by individual researchers. As discussed above, there are various aspects to research integrity and multiple actors involved. To better appreciate how research integrity reaches far beyond blatant misconduct, it can be useful to understand the prevalence of a range of poor research practices, from minor to severe. Outright fraud and data fabrication are rare in academic research. Retraction rates are typically around 0.02-0.16% (Grieneisen & Zhang, 2012) and only about 0.6% of researchers admit to falsifying data in anonymised surveys (John et al., 2012).

Even if these occurrences ceased entirely, academic research would still have many research integrity issues. For example, in an anonymised survey, many researchers admitted: failing to report all of a study's dependent measures (63%); deciding whether to stop data collection after checking if the results were significant (56%); failing to report all of a study's conditions (28%); and selectively reporting studies that 'worked' (46%, John et al., 2012).

Questionable research practices are one element, alongside poor understanding of statistics, which renders much of the published literature false or non-replicable. In large-scale replication projects, results are discrepant from the original study in many cases: for example, 61% (Open Science Collaboration, 2015), 72% (Klein et al., 2014) and 46% (Klein et al., 2018) in psychology, and 94% for brain-behaviour correlates (Boekel et al., 2015). The prevalence of questionable research practices, which can lead to the high rate of non-replicable findings, suggests that these behaviours are not sufficiently disincentivised in current research culture, and indeed may be incentivised to increase the likelihood of publication, career advancement and securing funding. In a survey of nearly a thousand researchers, 58% of respondents reported being "aware of scientists feeling tempted or under pressure to compromise on research integrity and standards" (Nuffield Council on Bioethics, 2014).

Alongside questionable research practices, 'overclaiming' of results may help advance a researcher's career and help secure funding. From 1947-2014 the prevalence of positive words in research paper abstracts increased from 2.0% to 17.5%, while negative words increased from 1.3% to 3.2% and neutral word occurrence did not change. Journals appear to encourage overclaiming through their policies. For example, the journal *Nature* has the acceptance criteria that manuscripts "are of outstanding scientific importance"[61] and states that the editors may "reject outright, typically on grounds of specialist interest, lack of novelty, insufficient conceptual advance…"[62]. The incentive to publish may lead to the situation where publications often claim novelty when multiple studies on the same topic have already been conducted (Robinson & Goodman, 2011). Some journals attempt to

[61] https://www.nature.com/nature/for-authors/editorial-criteria-and-processes
[62] https://www.nature.com/nature/for-referees/policies-and-processes

combat overclaiming by accepting any manuscript that is methodologically sound (for example, PLOS ONE[63]).

A study of institutional press releases revealed that 40% contain exaggerated advice, 33% contain exaggerated causal claims and 36% contain exaggerated inference from animal research to humans (Sumner et al., 2014). Whereas press officers write the releases, they do so in collaboration with researchers and there are many stages where the researcher could correct the report. The prevalence of over-claiming suggests that researchers are insufficiently incentivised to fulfil the honesty, transparency and openness elements of research integrity, as defined in the Concordat to Support Research Integrity.

Intrinsic personal motivation can drive some researchers to engage in good research practices, in pursuit of what is best for research as a whole. However, if selection pressures are stacked against these researchers (because selection is based on criteria incompatible with, or ignoring, research integrity) then they may lose their drive for research integrity or fail to secure their job as an academic researcher. This is more likely to impact on early career researchers. This argument is evidenced in the Nuffield Report on the Culture of Scientific Research in the UK, which documented that 26% of UK respondents "felt tempted or under pressure to compromise on research integrity and standards", and higher for early career researchers. 38% "think the 'pressure to publish' can encourage the fabrication of data, altering, omitting or manipulating data, or 'cherry-picking' results to report" and 31% "think there is pressure to focus on and report positive results, rather than negative results, and that researchers rushing to publish results may not conduct appropriate replications and scrutiny of their work" (Nuffield Council on Bioethics, 2014).

Many positive research activities that may take time and effort to achieve are only weakly or inconsistently incentivised by external forces, such as funders and institutions; therefore, these behaviours may stem from personal motivation. Such activities may include pre-registration, clear documentation, sharing of data and materials, peer review, training young researchers and public outreach through events and social media platforms. There has been some increase in platforms to support and measure these activities. The Open Science Framework[64] allows researchers to pre-register their study and share code. The website Publons[65] tracks peer-review contributions and had over 1,800,000 users as of August 2019. The website Altmetrics[66] tracks mentions of research online and activity on Twitter is also measurable in terms of followers, among other metrics. These metrics are rarely employed when evaluating researchers, but these data are readily available should a department, institution or funding agency decide they are important research performance metrics to consider.

Perceived disincentives can also stop individual researchers from engaging in best practice. For example, if a researcher makes their work more open and transparent (for example, by pre-registering studies, or publicly sharing and archiving research materials, protocols, code and data), others can more easily criticise their research practices and detect errors. Individual researchers may regard open practices as a risk to their reputation. In a survey of psychology researchers, 77% agreed that fear of alternative analyses exposing invalid conclusions was a barrier to sharing data openly in their field (Houtkoop et al., 2018). These

[63] https://journals.plos.org/plosone/s/journal-information
[64] https://osf.io/
[65] https://publons.com/
[66] https://www.altmetric.com/

fears may be unfounded, as the small amount of evidence in this area suggests that admitting to errors in one's work can be minimally harmful, or even helpful to one's reputation (see Bishop, 2018 for an overview). Other fields that use working papers and preprints, such as economics and physics, appear to have a more robust attitude towards challenges and self-correction. This reflects how (implicit) disciplinary cultures may influence the uptake and impact of initiatives (such as data sharing) intended to improve research integrity. However, how disciplines differ in terms of their culture for correction has not been well documented.

Many organisations, including UKRI, endorse the belief that achieving equality, diversity and inclusion (EDI) in the research environment is vital to producing the best possible research. However, individual characteristics such as gender, ethnicity and socioeconomic standing can often play a role in who remains in academia. Despite many institutions' stated commitments to diversity in all forms, unconscious (and sometimes conscious) bias on the basis of gender, race, ethnicity, disability and socioeconomic status exist in hiring and promotion decisions in society generally and within academia specifically. Moreover, diversity initiatives tend to focus on visible and easily measurable dimensions of diversity (such as gender and ethnicity), rather than those that are less visible and more difficult to measure (such as socioeconomic position). Initiatives such as blind review of funding applications can help, although they are not perfect solutions (Darling, 2015). The psychological burden of minority researchers striving to 'prove they belong' can lead to burnout, and feelings of exclusion can precipitate dropout. The informal nature of many of the mechanisms of research, moreover, means that unconscious biases regarding the demographics of a 'good researcher' can lead to researchers from minority groups receiving fewer opportunities for collaboration, awards and training that might positively influence their careers.

Questionable research practices are perceived to be widespread (John et al., 2012). A researcher may be personally motivated to have high research integrity, but cannot easily do so if it compromises their ability to maintain an academic career, publish, or secure funding. Engaging in good research practices can take time that could otherwise be spent on increasing research outputs. There is limited research on how individuals weigh the decision to employ high research standards against the drive to advance their career. For example, if a peer-reviewer or journal asks a researcher to describe how their results are novel, a researcher may feel obliged to do so even when the results are not necessarily novel. The researcher may perform a simple cost-benefit analysis and decide that the value of publishing their work is worth overclaiming its novelty. Overall, there are currently few disincentives for engaging in questionable research practices - especially because they are widespread - as well as few incentives to engage in high levels of research integrity.

8 Conclusion and gaps in the literature

Multiple actors are involved in research integrity in academia. While it is easy to focus on the behaviour of individual researchers, these actors play out on a landscape that includes a globalised research ecosystem, nation-specific regulations, institutional-level demands, disciplinary norms and departmental idiosyncrasies. Each of these levels contributes to research culture. It is clear that funders, institutions and researchers in the UK are interested in improving research integrity and instilling a healthy research culture. However, culture change is notoriously difficult to achieve with few incentives and concomitant rewards to drive positive behaviours.

There are multiple ongoing initiatives to improve research integrity in the UK. National-level organisations, including the government, have commissioned research to better understand the pressures and incentives in academic research. Funders, publishers and research institutions have implemented policies to improve research integrity. Researchers have begun to conduct studies on the process of research itself to better understand inefficiencies and lapses of integrity. Together, to some extent these initiatives provide: information on what researchers think about research culture; what institutions and researchers want the research ecosystem to look like; and what the research ecosystem actually looks like.

Nevertheless, there are gaps in the literature regarding how changes in research culture occur and how these changes can influence research integrity (including the potential for unintended consequences). For example, the impact that policies at various levels (for example, funder, publisher, institution, department) exert on research practices remains unclear. This is especially true for elements that are hard to measure objectively, such as socially undesirable behaviours that researchers are reticent to admit or self-report, or large sociological factors, such as high valuation of prestige, that are widely perceived anecdotally but difficult to objectively link causally to measurable outcomes. How to best implement policies, through mandates, incentives or other approaches, remains a crucial issue that could help improve research integrity if studied further. There is also little information on why various elements of research integrity are lacking: for instance, due to insufficient knowledge of best practice versus insufficient incentives. As global, national, institutional, departmental or other bodies enact policies intended to improve research integrity, it is vital that evidence be gathered as to their effects, which may entail designing and enacting these policies with such measurement in mind.

References

All European Academies (ALLEA). (2017). The European Code of Conduct for Research Integrity, 1–20. https://doi.org/10.1037/e648332011-002

Allen, C. & Mehler, D. M. A. (2019). Open science challenges, benefits and tips in early career and beyond. *PLOS Biology*, *17*(5), e3000246. https://doi.org/10.1371/journal.pbio.3000246

Bekelman, J. E. & Gross, C. P. (2003). Scope and Impact of Financial Conflicts of Interest in Biomedical Research. *JAMA: The Journal of the American Medical Association*, *289*(4), 454–465.

Bishop, D. V. M. (2018). Fallibility in Science: Responding to Errors in the Work of Oneself and Others. *Advances in Methods and Practices in Psychological Science*. https://doi.org/10.1177/2515245918776632

Boekel, W., Wagenmakers, E. J., Belay, L., Verhagen, J., Brown, S. & Forstmann, B. U. (2015). A purely confirmatory replication study of structural brain-behavior correlations. *Cortex*, *66*, 115–133. https://doi.org/10.1016/j.cortex.2014.11.019

Button, K. S. (2016). Statistical Rigor and the Perils of Chance. *ENeuro*, *3*(4), e0030-16.2016. https://doi.org/10.1523/ENEURO.0030-16.2016

Button, K. S., Ioannidis, J. P. A., Mokrysz, C., Nosek, B. a, Flint, J., Robinson, E. S. J. & Munafò, M. R. (2013). Power failure: why small sample size undermines the reliability of neuroscience. *Nature Reviews. Neuroscience*, *14*(5), 365–376. https://doi.org/10.1038/nrn3475

Cadez, S., Dimovski, V. & Groff, M. Z. (2017). Studies in Higher Education Research, teaching and performance evaluation in academia : the salience of quality, *5079*. https://doi.org/10.1080/03075079.2015.1104659

Carayol, N. & Matt, M. (2006). Individual and collective determinants of academic scientists' productivity. *Information Economics and Policy*, *18*(1), 55–72. https://doi.org/10.1016/j.infoecopol.2005.09.002

Chambers, C. D. (2013). Registered Reports: A new publishing initiative at Cortex. *Cortex*. https://doi.org/10.1016/j.cortex.2012.12.016

Chavalarias, D., Wallach, J. D., Li, A. H. T. & Ioannidis, J. P. A. (2016). Evolution of reporting P values in the biomedical literature, 1990-2015. *JAMA - Journal of the American Medical Association*, *315*(11), 1141–1148. https://doi.org/10.1001/jama.2016.1952

Crain A. L., Martinson, B. C. & Thrush, C. R. (2013) Relationships Between the Survey of Organizational Research Climate (SORC) and Self-Reported Research Practices. *Sci Eng Ethics.* 2013 Sep; 19(3): 835–850.

Darling, E. S. (2015). Use of double-blind peer-review to increase author diversity. *Conservation Biology*, *29*(1), 297–299. https://doi.org/10.1111/cobi.12333

Duyx, B., Urlings, M. J. E., Swaena, G. M. H., Bouter, L. M., Zeegers, M. P. (2017). Scientific citations favor positive results: a systematic review and meta-analysis. *Journal of Clinical Epidemiology* 88 92-101. https://doi.org/10.1016/j.jvlinepi.2017.06.002

European Commission: Working Group on Education and Skills under Open Science. (2017). Providing researchers with the skills and competencies they need to practise Open Science. European Commission. https://doi.org/10.2777/121253

European Commission. (2017). *Evaluation of Research Careers fully acknowledging Open Science Practices*. https://doi.org/10.2777/75255

Fanelli, D. (2010). "Positive" results increase down the hierarchy of the sciences. *PLOS ONE*, *5*(4). https://doi.org/10.1371/journal.pone.0010068

Finch, J. (2010) et al. Report of the UK Research Integrity Futures Working Group. Retrieved from https://www.ukri.org/about-us/policies-and-standards/research-integrity/

Fire, M. & Guestrin, C. (2019). Over-optimization of academic publishing metrics: observing Goodhart's Law in action. *GigaScience*, *8*(6), 1–20. https://doi.org/10.1093/gigascience/giz053

Fraser, N., Momeni, F., Mayr, P. & Peters, I. (2019). The effect of bioRxiv preprints on citations and altmetrics. *BioRxiv*.

Gaind, N. (2018). Few UK universities have adopted rules against impact-factor abuse. *Nature*. https://doi.org/10.1038/d41586-018-01874-w

Goldacre, B., Devito, N. J., Heneghan, C., Irving, F., Bacon, S., Fleminger, J. & Curtis, H. (2018). Compliance with requirement to report results on the EU Clinical Trials Register: Cohort study

and web resource. *BMJ (Online)*, *362*. https://doi.org/10.1136/bmj.k3218
Goldacre, B., Drysdale, H., Dale, A., Milosevic, I., Slade, E., Hartley, P., … Mahtani, K. R. (2019). COMPare: A prospective cohort study correcting and monitoring 58 misreported trials in real time. *Trials*, *20*(1), 1–16. https://doi.org/10.1186/s13063-019-3173-2
Gorgolewski, K. J., Varoquaux, G., Rivera, G., Schwarz, Y., Ghosh, S. S., Maumet, C., … Margulies, D. S. (2015). NeuroVault.org: a web-based repository for collecting and sharing unthresholded statistical maps of the human brain. *Frontiers in Neuroinformatics*, *9*(April), 1–9. https://doi.org/10.3389/fninf.2015.00008
Graves, N., Barnett, A. G. & Clarke, P. (2011). Funding grant proposals for scientific research: Retrospective analysis of scores by members of grant review panel. *BMJ (Online)*, *343*(7825), 1–8. https://doi.org/10.1136/bmj.d4797
Grieneisen, M. L. & Zhang, M. (2012). A Comprehensive Survey of Retracted Articles from the Scholarly Literature. *PLOS ONE*, *7*(10). https://doi.org/10.1371/journal.pone.0044118
Hale, C., Arrowsmith, J., Bayes, S., Bodmer, H., Garman, A., Hubbard, P., … Sooben, P. (2012). *The concordat to support research integrity*. *Universities UK*.
Hardwicke, T. E., Wallach, J. D., Kidwell, M. C. & Ioannidis, J. P. A. (2019). An empirical assessment of transparency and reproducibility-related research practices in the social sciences (2014-2017). *MetaArXiv*, 1–22. https://doi.org/10.31222/osf.io/6uhg5
Head, M. L., Luke Holman, L., Lanfear, R., Kahn, A. T., Jennions, M. D. (2015). The Extent and Consequences of P-Hacking in Science. *PLOS,* https://doi.org/10.1371/journal.pbio.1002106
HEFCE, RCUK, UUK & Wellcome. (2016). *Concordat On Open Research Data*. Retrieved from http://www.rcuk.ac.uk/documents/documents/concordatonopenresearchdata-pdf/
Herbert, D. L., Barnett, A. G., Clarke, P. & Graves, N. (2013). On the time spent preparing grant proposals: An observational study of Australian researchers. *BMJ Open*, *3*(5), 1–6. https://doi.org/10.1136/bmjopen-2013-002800
Hicks, D., Wouters, P., Waltman, L., De Rijcke, S. & Rafols, I. (2015). Bibliometrics: The Leiden Manifesto for research metrics. *Nature*. https://doi.org/10.1038/520429a
Holcombe, A. (2019). Farewell authors, hello contributors. *Nature*, *571*(7764), 147–147. https://doi.org/10.1038/d41586-019-02084-8
House of Commons Science and Technology Committee. (2018). *Research integrity Sixth Report of Session 2017-19*. Retrieved from www.parliament.uk/science
House of Commons Science and Technology Committee (2018). *Research integrity: Government and UK Research and Innovation Responses to the Committee's Sixth Report*.
Houtkoop, B. L., Chambers, C., Macleod, M., Bishop, D. V. M., Nichols, T. E. & Wagenmakers, E.-J. (2018). Data Sharing in Psychology: A Survey on Barriers and Preconditions. *Advances in Methods and Practices in Psychological Science*. https://doi.org/10.1177/2515245917751886
Iqbal, S. A., Wallach, J. D., Khoury, M. J., Schully, S. D. & John, P. (2016). Reproducible Research Practices and Transparency across the Biomedical Literature, 1–13. https://doi.org/10.1371/journal.pbio.1002333
John, L. K., Loewenstein, G. & Prelec, D. (2012). Measuring the Prevalence of Questionable Research Practices With Incentives for Truth Telling. *Psychological Science*, *23*(5), 524–532. https://doi.org/10.1177/0956797611430953
Jump, P. (2013). Twenty per cent contracts rise in run-up to REF. *Times Higher Education*. Retrieved from https://www.timeshighereducation.com/news/twenty-per-cent-contracts-rise-in-run-up-to-ref/2007670.article
Kaplan, R. M. & Irvin, V. L. (2015). Likelihood of null effects of large NHLBI clinical trials has increased over time. *PLOS ONE*, *10*(8), 1–12. https://doi.org/10.1371/journal.pone.0132382
Kidwell, M. C., Lazarević, L. B., Baranski, E., Hardwicke, T. E., Piechowski, S., Falkenberg, L. S., … Nosek, B. A. (2016). Badges to Acknowledge Open Practices: A Simple, Low-Cost, Effective Method for Increasing Transparency. *PLOS Biology*, *14*(5), 1–15. https://doi.org/10.1371/journal.pbio.1002456
Klein, R. A., Ratliff, K. A., Vianello, M., Adams, R. B., Bahník, Š., Bernstein, M. J., … Nosek, B. A. (2014). Investigating variation in replicability: A "many labs" replication project. *Social Psychology*, *45*(3), 142–152. https://doi.org/10.1027/1864-9335/a000178
Klein, R. A., Vianello, M., Hasselman, F., Adams, B. G., Adams, R. B., Alper, S., … Nosek, B. A. (2018). Many Labs 2: Investigating Variation in Replicability Across Samples and Settings. *Advances in Methods and Practices in Psychological Science*, *1*(4), 443–490.

https://doi.org/10.1177/2515245918810225
Kramer, A. D. I., Guillory, J. E. & Hancock, J. T. (2014). Experimental evidence of massive-scale emotional contagion through social networks. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(24), 8788–8790. https://doi.org/10.1073/pnas.1320040111
Lariviere, V., Kiermer, V., MacCallum, C. J., McNutt, M., Patterson, M., Pulverer, B., … Curry, S. (2016). A simple proposal for the publication of journal citation distributions. *BioRxiv*, 062109. https://doi.org/10.1101/062109
Lesser, L. I., Ebbeling, C. B., Goozner, M., Wypij, D. & Ludwig, D. S. (2007). Relationship between funding source and conclusion among nutrition-related scientific articles. *PLOS Medicine*, *4*(1), 0041–0046. https://doi.org/10.1371/journal.pmed.0040005
Lewis, D. (2017). Funding debate over paper quality vs quantity. *Nature Index*. Retrieved from https://www.natureindex.com/news-blog/funding-debate-over-paper-quality-vs-quantity
Macleod, M. R., Lawson McLean, A., Kyriakopoulou, A., Serghiou, S., de Wilde, A., Sherratt, N., … Sena, E. S. (2015). Risk of Bias in Reports of In Vivo Research: A Focus for Improvement. *PLOS Biology*, *13*(10), 1–12. https://doi.org/10.1371/journal.pbio.1002273
Maher, B. & Sureda Anfres, M. (2016). Under Pressure. *Nature*, *538*, 444–445. https://doi.org/10.1038/538444a
Mathieu, S., Chan, A. W. & Ravaud, P. (2013). Use of Trial Register Information during the Peer Review Process. *PLOS ONE*, *8*(4), 2–5. https://doi.org/10.1371/journal.pone.0059910
McKiernan, E., Schimanski, L., Matthias, L. & Niles, M. (2019). Use of the Journal Impact Factor in academic review, promotion and tenure evaluations. *ELife*, 1–12. https://doi.org/10.7287/peerj.preprints.27638
Medical Research Council. (2016). Guidance for applicants: 2. The application. Retrieved 5 August 2019 from https://mrc.ukri.org/funding/guidance-for-applicants/2-the-application/#2.2.3.4
Niso, G., Rogers, C., Moreau, J. T., Chen, L. Y., Madjar, C., Das, S., … Baillet, S. (2016). OMEGA: The Open MEG Archive. *NeuroImage*, *124*, 1182–1187. https://doi.org/10.1016/j.neuroimage.2015.04.028
Nosek, B. A., Alter, G., Banks, G. C., Borsboom, D., Bowman, S. D., Breckler, S. J., … Yarkoni, T. (2015). Promoting an open research culture. *Science*. https://doi.org/10.1126/science.aab2374
Nuffield Council on Bioethics. (2014). The Culture of Scientific Research in the UK.
Nurse, P. (2015). Ensuring a successful UK research endeavour - A Review of the UK Research Councils, 1–33. https://doi.org/https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/478125/BIS-15-625-ensuring-a-successful-UK-research-endeavour.pdf
Ofir, Z., Schwandt, T., Duggan, C. & McLean, R. (2016). Research Quality Plus: A Holistic Approach to Evaluating Research. *International Development Research Center Canada*, 1–6.
Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science*, *349*(6251), aac4716–aac4716. https://doi.org/10.1126/science.aac4716
Parliament of the United Kingdom. Human Fertilisation and Embryology Act 1990 (1990).
Peters, D. P. & Ceci, S. J. (1982). Peer-review practices of psychological journals The fate of published articles, submitted again. *Behavioural and Brain Sciences*, *5*, 187–255.
Peters, I., Frodeman, R., Wilsdon, J., Bar-Ilan, J., Lex, E., Wouters, P., (2017) Next generation metrics. European Commission. https://publications.europa.eu/en/publication-detail/-/publication/b858d952-0a19-11e7-8a35-01aa75ed71a1
Piwowar, H., Priem, J., Larivière, V., Alperin, J. P., Matthias, L., Norlander, B., … Haustein, S. (2018). The state of OA: a large-scale analysis of the prevalence and impact of Open Access articles. *PeerJ*, *6*, e4375. https://doi.org/10.7717/peerj.4375
Powell, K. (2016). The waiting game. *Nature*, *530*(148). https://doi.org/10.1038/429010a
Prinz, F., Schlange, T. & Asadullah, K. (2011). Believe it or not : how much can we rely on published data on potential drug targets ? *Nature Publishing Group*. https://doi.org/10.1038/nrd3439-c1
Robinson, K. A. & Goodman, S. N. (2011). A systematic examination of the citation of prior research in reports of randomized, controlled trials. *Annals of Internal Medicine*. https://doi.org/10.7326/0003-4819-154-1-201101040-00007
Schwarzkopf, S. (2016). It's not the end of the world if your research gets 'scooped'. *Times Higher Education*.
Science and Technology Commission. (2018). Research integrity: clinical trials transparency Tenth Report of Session 2017-19, together with formal minutes relating to the report (October).

Retrieved from www.parliament.uk/science
Siontis, K. C. & Ioannidis, J. P. A. (2018). Replication, Duplication and Waste in a Quarter Million Systematic Reviews and Meta-Analyses. *Circulation. Cardiovascular Quality and Outcomes*. https://doi.org/10.1161/CIRCOUTCOMES.118.005212
Smaldino, P. E. & McElreath, R. (2016). The Natural Selection of Bad Science. https://doi.org/10.1098/rsos.160384
Stavropoulou, C., Somai, M. & Ioannidis, J. P. A. (2019). Most UK scientists who publish extremely highly-cited papers do not secure funding from major public and charity funders: A descriptive analysis. *PLOS ONE*, *14*(2), 1–11. https://doi.org/10.1371/journal.pone.0211460
Steneck, N. H. (2013). Global research integrity training. *Science*, *340*(6132), 552–553. https://doi.org/10.1126/science.1236373
Sumner, P., Vivian-Griffiths, S., Boivin, J., Williams, A., Venetis, C. A., Davies, A., … Chambers, C. D. (2014). The association between exaggeration in health related science news and academic press releases: Retrospective observational study. *BMJ (Online)*. https://doi.org/10.1136/bmj.g7015
Taylor, M. & Wedel, M. (2015). How can next REF more strongly emphasise the unimportance of Impact Factor? Retrieved 5 August 2019 from https://svpow.com/2015/07/10/how-can-next-ref-more-strongly-emphasise-the-unimportance-of-impact-factor/
Techopolis. (2019). International Landscape Study of Research and Innovation Systems.
The Lancet. (2019). Assessing researchers with a focus on research integrity. *The Lancet*, *393*(10181), 1570. https://doi.org/10.1016/S0140-6736(19)30862-1
The PLOS Biology Staff. (2018). The importance of being second. *PLOS Biology*, *16*(1). https://doi.org/10.1371/journal.pbio.2005203
The Royal Society. (2018a). Integrity in practice toolkit.
The Royal Society. (2018b). Research culture : changing expectations Conference report.
Times Higher Education. (2011). Citation averages, 2000-2010, by fields and years. Retrieved 2 August 2019 from https://www.timeshighereducation.com/news/citation-averages-2000-2010-by-fields-and-years/415643.article
UKRIO. (2018) Use of UKRIO Advisory Service; Summary data 2007-2016
Understanding Animal Research. (2014). Concordat on Openness on Animal Research in the UK.
Van Dijk, D., Manor, O. & Carey, L. B. (2014). Publication metrics and success on the academic job market. *Current Biology*, *24*(11), R516–R517. https://doi.org/10.1016/j.cub.2014.04.039
Vitae. (2011). The Concordat to Support the Career Develpoment of Researchers.
Vitae. (2017). Five Steps Forward: Progress in implementing the Conocrdat to Support the Career Development of Researchers 2008- 2017
Wager, E. (2019). UK universities compliance with the Concordat to Support Research Integrity: findings from cross-sectional time-series. *PeerJ Preprints*. https://doi.org/10.7287/peerj.preprints.27622
Wallach, J. D., Boyack, K. W. & Ioannidis, J. P. A. (2018). Reproducible research practices, transparency and open access data in the biomedical literature, 2015–2017. *PLOS Biology*, *16*(11), 2015–2017. https://doi.org/10.1371/journal.pbio.2006930
Weinstein, N., Wilsdon, J., Chubb, J. & Haddock, G. (2019). The Real Time REF Review: A Pilot Study to Examine the Feasibility of a Longitudinal Evaluation of Perceptions and Attitudes Towards REF 2021 - Executive Summary June 2019, (June). Retrieved from https://re.ukri.org/news-events-publications/publications/real-time-ref-review-pilot-study/
Wells, J., Thrush, C. R., Martinson, B. C., May, T. A., …, (2014). Survey of organizational research climates in three research intensive, doctoral granting universities. *J Empir Res Hum Res Ethics*. 2014 Dec;9(5):72-88. doi: 10.1177/1556264614552798.
Wilsdon, J., Allen, L., Belfiore, E., Campbell, P., Curry, S., Hill, S., … Johnson, B. (2017). The Metric Tide: Independent Review of the Role of Metrics in Research Assessment and Management. HEFCE. https://doi.org/10.4135/9781473978782
Wislar, J. S., Flanagin, A., Fontanarosa, P. B. & DeAngelis, C. D. (2011). Honorary and ghost authorship in high impact biomedical journals: A cross sectional survey. *BMJ (Online)*, *343*(7835), 1–7. https://doi.org/10.1136/bmj.d6128
Zbar, A. & Frank, E. (2011). Significance of authorship position: An open-ended international assessment. *American Journal of the Medical Sciences*, *341*(2), 106–109. https://doi.org/10.1097/MAJ.0b013e3181f683a1

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