



## Research

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# Awareness and use of open research practices: an international survey of researchers across disciplines

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This mixed methods study investigates international researchers' awareness and use of open research practices and explores variations across regions, disciplines, methodologies and career stages. A total of 3017 researchers across 45 countries and 24 disciplines completed the Brief Open Research Survey, reporting their awareness and use of 11 common open research practices and factors that would support their adoption. Across the sample, respondents reported high awareness of open access publications, preprints and open data, and awareness only fell below 50% for research co-production and registered reports. Use was high for open access publications, but fell below 50% for preprints, open data, open research, open materials, open peer review, open code, preregistration, research co-production, replication and registered reports. Awareness and use varied across the sampled regions (e.g. Europe versus Asia), disciplines (e.g. psychology versus physical sciences), methodologies (e.g. quantitative versus qualitative) and career stages (e.g. PhD students versus professors). Respondents reported that the top five supportive strategies were incentives from funders, institutions and regulators; dedicated funding; recognition in promotion and recruitment criteria; more training; and more information. Qualitative responses provide insight into challenges and opportunities. Estimates of awareness can guide training initiatives, while estimates of use can inform policy development and longitudinal evaluations of behaviour change. Variations between regions, disciplines, methodologies and career stages should be acknowledged.

## 1. Introduction

Concerns regarding the replicability, reproducibility and transparency of research are not new [1] but have reached a critical point owing to large-scale and sustained evidence of replication and reproducibility 'failures' (e.g. [2–5]), identification of questionable research practices (QRPs) [6,7], cases of academic misconduct (e.g. [8,9]) and the low prevalence of data sharing [10,11]. As we discuss herein, some of these

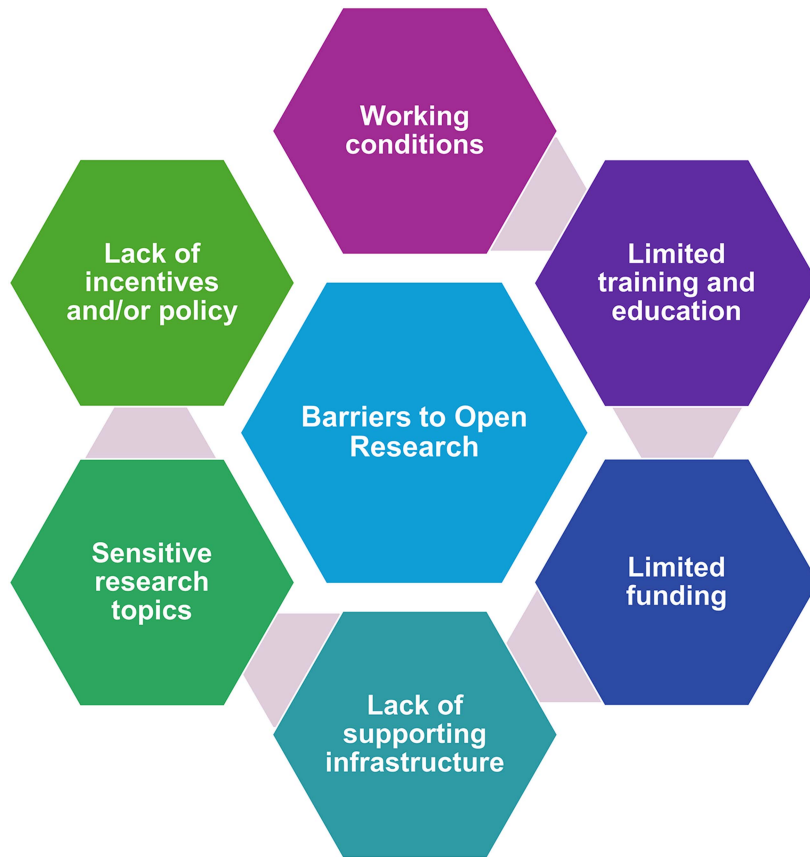
issues may be more relevant to certain methodologies (e.g. quantitative versus qualitative research) and even in different disciplines and countries (e.g. for ‘high stakes’ research or hyper-competitive environments), but there is consensus that institutional and cultural factors shape the norms of research practice, and that improvements are necessary [12–16]. Open research has been leveraged as one potential improvement to this so-called ‘replication/reproducibility crisis’, sparking procedural, community and structural change [17].

Open research reflects the notion that knowledge of all kinds, where appropriate, should be openly accessible, transparent, rigorous, reproducible, replicable, cumulative and inclusive [18]. This term has broadened from ‘open science’ to encompass *all* research disciplines, and ‘open scholarship’ is used in the context of teaching and pedagogy. Open research encompasses a set of practices and behaviours with the goal of improving the research ecosystem [16,19]. Focusing on practices, there has been critical discussion of how preregistration [20,21], registered reports [22,23], open materials, code and data [24,25], preprints [26] and open access (OA) publication [27] can bolster research integrity and widen access (see [28,29,30] for critical perspectives). To facilitate awareness and use of such practices, researchers have developed various guides (e.g. [31–33]), large-scale infrastructures (e.g. Open Science Framework [34]) and community-led networks (e.g. ReproducibiliTEA journal clubs [35]; Framework for Open and Reproducible Research Training [36]).

In recent years, open research has been advanced by major organizations and consortia through global policies and recommendations, mainly from developed countries (e.g. Global Federation of Reproducibility Networks [see 37]). Many began with specific recommendations to support OA publishing and open data (e.g. 2001 Budapest OA Initiative; see [38] for a timeline), which have since broadened to encompass a wider range of practices. For example, in 2021, UNESCO developed their ‘*Recommendation on Open Science*’, providing an internationally agreed definition, set of shared values and guiding principles for open research [39]. Similarly, the European University Association [40] has developed an Open Science Agenda for 2025 and beyond, which defines priorities and describes the current context, challenges and developments. Open research is now a legal obligation under Horizon Europe—the EU’s key funding programme for research and innovation [41,42]. Initiatives have also been implemented by publishers and funders, such as open research badges [43], the Transparency and Openness Promotion guidelines [44,45], community journals and peer review (e.g. Peer Community In), Registered Reports funding partnerships [46] as well as changes to research assessment exercises (e.g. San Francisco Declaration on Research Assessment [47]; Coalition for Advancing Research Assessment) and funding for meta-research (e.g. [48,49]; German Research Foundation [see 37]).

Engaging in open research requires behaviour change [19], and empirical studies have begun to assess researchers’ awareness, use and perceptions of such practices (e.g. [50–54]). Norris *et al.* [53] developed the Brief Open Research Survey (BORS) to assess awareness and use of 11 common open research practices as well as strategies that support their adoption. Across a sample of 1274 multi-disciplinary UK researchers, over half were aware of OA publications, preprints, open materials, code and data, open peer review, open research, replication studies, research co-production and preregistration, but less than half were aware of Registered Reports. However, only OA publications, preprints and open data reached >50% use, consistent with other studies suggesting a gap between awareness and practice [50,52]. Respondents reported that incentives from funders, institutions and other regulators, dedicated funding and recognition in promotion and recruitment criteria would support them most in adopting open research. Ferguson *et al.* [55] surveyed European researchers selected from the top 10 most-cited journals in the social sciences and found substantially higher estimates, with greater engagement with open data and code than preregistration and an increase in lifetime prevalence over a decade. Some research has investigated variation in these practices based on region, discipline and methodology: in a sample of 452 professors, Chakravorti *et al.* [51] found greater self-reported use of preregistration in the social sciences compared to engineering as well as regional variation in this practice between the USA and India (the only two disciplines and regions sampled). In a sample of 602 psychology researchers from the UK and Ireland, Silverstein *et al.* [54] found higher engagement for those whose primary methodology was quantitative compared to qualitative and those with institutional support for open research. Despite providing important insights, these studies are limited by their focus on specific countries, regions or disciplines and/or selective sampling.

There is therefore a need to estimate awareness and use of open research across researchers from different regions, disciplines and methodologies. This is particularly important because access to participation may not be equal and may even create new inequalities. Researchers across different world regions face unique challenges that—although not exclusive to open research—can limit participation



**Figure 1.** Potential barriers to engaging in open research.

[56–58]. Chuan-Peng *et al.* [56] discuss several micro-level barriers that can specifically impact researchers from lower-middle income countries to engage in open research, such as limited institutional support, time constraints, poor working conditions, inadequate infrastructure and training, as well as a lack of incentive, visibility and sustainability. This is supported by a recent White paper indicating disparities in research integrity training between high- and lower-middle-income countries [59]. Participation in some open research practices may be impacted more than others; researchers may have limited or no funding to cover article processing charges, with only a few journals offering waivers or discounts, and some applying specific eligibility criteria. It has also been argued that, owing to current incentive structures, there are indirect costs associated with the adoption of preregistration, Registered Reports and code/data sharing, such as time, labour and recognition [60–62]. This may be particularly challenging for researchers on temporary contracts or under significant funding and time restraints: for example, researchers perceive that a key barrier to implementing Registered Reports is their extended timeline for peer review [63], although new initiatives have been implemented to mitigate this [22,64]. Furthermore, in some countries and disciplines, and at different career stages, there may be cultural barriers to engaging in open research; access to infrastructure is not globally equitable, regulatory frameworks surrounding open data differ, competitive rather than collaborative modes of research are common, and researchers at early career stages may fear persecution [57,65].

Recent discussions have also highlighted that engaging with open research may not be appropriate for all types of research, suggesting differences between disciplines, methodologies and specific research studies [66,67–69]. It has been argued that open research practices predominantly focus on quantitative, confirmatory research [68], where practices, such as replication, preregistration and open data, aim to limit undisclosed, *post hoc* analytical flexibility [70,71]. Moreover, several issues that have driven the reproducibility crisis, such as publication incentives centring on statistically significant findings [72], do not apply to qualitative research [71,68]. Open data are constrained by sensitive topics where participants could be easily identified (e.g. clinical populations [73]) or in disciplines where open knowledge could be misused (e.g. synthetic biology, nuclear physics [74–76]). This aligns with the European Commission's ethos of 'as open as possible, as closed as necessary' [41]. Figure 1 visualizes these potential barriers.

## 2. Research overview

Few studies have assessed awareness and use of common open research practices across regions, methodologies, disciplines and career stages. We therefore utilized the BORS [53] to conduct a mixed methods study in a large, international multidisciplinary sample. Drawing on the COM-B model of behaviour change [77], we further explored what support would help researchers to use more open research practices. In this context, Psychological Capability refers to an individual perceiving that they have the ability and skills to participate in open research practices; Physical Opportunity relates to the external factors that make using these practices possible; Social Opportunity relates to the social factors, such as cultural norms and cues, that encourage open research; and Reflective Motivation refers to the cognitive processes that direct and inspire open research practices, such as the extent to which these behaviours align with personal goals and values [53],<sup>1</sup> [54]. By providing estimates of awareness and use of open research across different boundaries, our research aims to inform education, training and policy while also highlighting areas in which the open research landscape should acknowledge and mitigate inequalities.

## 3. Methods

### 3.1. Openness and transparency statement

This study was prospectively registered on the Open Science Framework on 14 June 2023 (<https://osf.io/2ewz6> [78]), and data collection began on 26 June 2023. There were three deviations from the pre-registration: first, we extended the data collection deadline twice; second, we expanded our survey distribution strategy so that researchers who were not members of regional reproducibility networks (<https://www.ukrn.org/global-networks>) could also disseminate the survey; and third, we report the data by world region rather than country. Given the descriptive aims of this study, these deviations do not introduce researcher bias but instead strengthen the robustness of our findings by increasing sample size and representativeness [79]. In line with the recommendations of Simmons et al. [80], we report how we determined our sample size, all data exclusions and all measures. We report our findings in line with the Checklist for Reporting of Survey Studies guidelines [81] (see supplementary material). All materials, code, data and supplementary material are available at: <https://osf.io/njt37/> [82]. The raw data have been anonymized to redact any potentially identifiable information (e.g. institution/department name). Certain variables have been split between datasets, and a randomizer has been applied to uphold anonymity. It is important to note that an additional reason we decided to restrict the sharing of aggregate data is to prevent the potential ranking of open research practices (e.g. by institution, given the barriers shown in figure 1).

### 3.2. Sampling strategy and participants

The study was granted ethical approval from the lead institutions (refs: 36606-LR-May/2022-39378-2; 36606-A-May/2023-44788-1), and all respondents provided informed consent. To be eligible to take part, respondents had to be aged 18 and over and an active researcher at PhD candidate level or above. The survey was open to all researchers regardless of prior familiarity with open research. In line with Norris et al. [53], we aimed to recruit a large sample size via convenience sampling. Respondents did not report their age, gender or ethnicity because these were not a focus of the study.

After applying preregistered exclusion criteria (see §4.2), the final sample size comprised 3017 respondents from a total of 24 disciplines and 45 countries. Table 1 reports respondent demographics and figure 2 visualizes the sample size by country.

### 3.3. Procedure

An invitation was sent to international affiliates of the UK Reproducibility Network (see <https://www.ukrn.org/international-networks/>) to collaborate on this project. This approach was initially selected because RNs have a global reach and present a unique opportunity to distribute widely. A total of 20

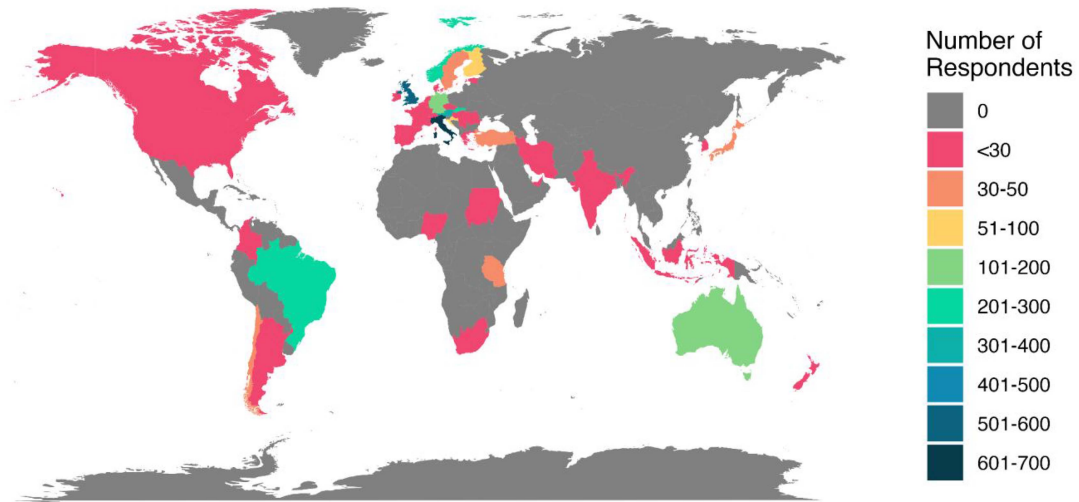
<sup>1</sup>The COM-B model also includes physical capability (having the strength, stamina or dexterity needed to perform a behaviour) and automatic motivation (arising from automatic impulses and associative learning), which were not thought to align with open research practices.

**Table 1.** Respondent demographics.

| Country        | N (%)        | Discipline                           | N (%)         |
|----------------|--------------|--------------------------------------|---------------|
| Italy          | 625 (20.72%) | Psychology                           | 645 (21.38%)  |
| United Kingdom | 503 (16.67%) | Biological & Sports Sciences         | 342 (11.34%)  |
| Austria        | 309 (10.24%) | Social Sciences                      | 269 (8.92%)   |
| Brazil         | 295 (9.78%)  | Medicine & Dentistry                 | 257 (8.52%)   |
| Slovakia       | 271 (8.98%)  | Subjects allied to Medicine          | 202 (6.70%)   |
| Norway         | 202 (6.70%)  | Physical Sciences                    | 157 (5.20%)   |
| Germany        | 186 (6.17%)  | Education & Teaching                 | 156 (5.17%)   |
| Australia      | 167 (5.54%)  | Engineering & Technology             | 154 (5.10%)   |
| Finland        | 57 (1.89%)   | Language & Area Studies              | 101 (3.35%)   |
| Croatia        | 56 (1.86%)   | General and others in Sciences       | 89 (2.95%)    |
| Chile          | 40 (1.33%)   | Business & Management                | 86 (2.85%)    |
| Turkey         | 35 (1.16%)   | Humanities & Liberal Arts            | 81 (2.69%)    |
| Sweden         | 34 (1.13%)   | Mathematical Sciences                | 73 (2.42%)    |
| Japan          | 34 (1.13%)   | Geographical & Environmental Studies | 65 (2.15%)    |
| Tanzania       | 34 (1.13%)   | Agriculture, Food & related studies  | 64 (2.12%)    |
| Switzerland    | 27 (0.89%)   | Computing                            | 64 (2.12%)    |
| Netherlands    | 23 (0.76%)   | Historical, Philosophical & R.S.     | 43 (1.43%)    |
| United States  | 22 (0.73%)   | Law                                  | 42 (1.39%)    |
| Belgium        | 20 (0.66%)   | Veterinary Sciences                  | 25 (0.83%)    |
| Canada         | 10 (0.33%)   | Combined & General Studies           | 23 (0.76%)    |
| New Zealand    | 9 (0.30%)    | Architecture, Building & Planning    | 21 (0.70%)    |
| South Africa   | 6 (0.20%)    | Creative Arts & Design               | 20 (0.66%)    |
| Ireland        | 5 (0.17%)    | Communications & Media               | 16 (0.53%)    |
| Serbia         | 5 (0.17%)    | General/Others                       | 14 (0.46%)    |
| India          | 4 (0.13%)    |                                      |               |
| Spain          | 4 (0.13%)    |                                      |               |
| Czech Republic | 2 (0.07%)    | <b>Methodology</b>                   | <b>N (%)</b>  |
| Denmark        | 2 (0.07%)    | Quantitative                         | 1268 (42.03%) |
| France         | 2 (0.07%)    | Mixed Methods                        | 1226 (40.64%) |
| Indonesia      | 2 (0.07%)    | Qualitative                          | 371 (12.30%)  |
| Balkans        | 1 (0.03%)    | Other                                | 51 (1.69%)    |
| Argentina      | 1 (0.03%)    |                                      |               |
| China          | 1 (0.03%)    |                                      |               |
| Columbia       | 1 (0.03%)    | <b>Career Level</b>                  | <b>N (%)</b>  |
| Estonia        | 1 (0.03%)    | PhD Student                          | 696 (23.07%)  |
| Greece         | 1 (0.03%)    | Professor                            | 527 (17.47%)  |
| Hong Kong      | 1 (0.03%)    | Temporary Research-Only              | 475 (15.74%)  |
| Hungary        | 1 (0.03%)    | Reader/Associate Professor           | 417 (13.82%)  |
| Iran           | 1 (0.03%)    | Lecturer/Assistant Professor         | 281 (9.31%)   |
| Nigeria        | 1 (0.03%)    | Senior Lecturer                      | 199 (6.60%)   |
| Portugal       | 1 (0.03%)    | Permanent Research-Only              | 178 (5.90%)   |
| Romania        | 1 (0.03%)    | Other                                | 150 (4.97%)   |
| South Korea    | 1 (0.03%)    | Associate Lecturer/Adjunct Professor | 61 (2.02%)    |
| Sudan          | 1 (0.03%)    |                                      |               |
| UAE            | 1 (0.03%)    | <b>Involved in a research group</b>  | <b>N (%)</b>  |
|                |              | Yes                                  | 1407 (46.64%) |
|                |              | No                                   | 1564 (51.84%) |
|                |              | <b>Involved in OR initiatives</b>    | <b>N (%)</b>  |
|                |              | Yes                                  | 601 (19.92%)  |
|                |              | No                                   | 2379 (78.85%) |

Country = place of primary university/institution affiliation; UAE = United Arab Emirates; R.S. = religious studies; OR = open research. Percentages do not add to 100% owing to missing data. Disciplines are categorized in accordance with the UK's Higher Education Statistics Agency's Common Aggregation Hierarchy, Level 1 [83].

countries with current RN leads were contacted using their organizational/institutional email addresses, and a total of 15 countries signed up through this sampling strategy: Germany, Slovakia, Norway, Sweden, Australia, The Netherlands, Croatia, Finland, Brazil, Italy, Austria, Canada, Portugal, Switzerland and the UK. These leads then disseminated the survey through their institutional mailing lists, newsletters, research groups, working groups, collaborators and internal communications teams. Social media



**Figure 2.** Sample size by country. Figure created in R (version 4.5.2, 10-31-2025).

announcements were restricted to official Slack groups (<https://slack.com/>) to avoid data quality issues outlined in Silverstein et al. [54]. Shortly after, we extended our sampling strategy so that additional collaborators outside of the RN, who expressed interest, could disseminate the survey, with representation increasing to 45 countries in total. The survey was presented in English for 41 countries, and four countries translated the survey to their local language (Turkey, Brazil, Slovakia and Croatia), with one researcher conducting the first translation, a second researcher conducting a back translation, and the lead for that country conducting final checks.

The survey was administered via Qualtrics [84] and was available to complete for 29 weeks. Respondents were informed that their participation was voluntary, responses would be anonymized, and that they could withdraw at any time. They were also informed that their local RNs or country lead would receive a summary of responses to inform internal practice and policy development and that the full anonymized dataset would be made openly available.

## 4. Materials

### 4.1. Brief Open Research Survey

The BORS [53]<sup>2</sup> is a standardized questionnaire to assess awareness and use of open research practices. It is designed to be completed quickly (<5 minutes) to reduce burden while providing a detailed snapshot of open research practices at the sampled time point. In the current study, we utilized this survey in a cross-sectional design.

The survey begins by asking a series of demographic questions (see 'Materials', <https://osf.io/njt37>). It then presents respondents with 11 open science practices (figure 3) and asks, 'Which of the following research practices are you aware of? (Tick all that apply)'. Each open research practice is displayed with a brief definition, and respondents select 'I am aware of this' by ticking the corresponding box or leaving this blank if they are unaware of the practice. If a respondent reports that they are aware of a practice, they are shown these specific practices again and asked, 'Which of the research practices have you used, in your own research or in a collaboration with others? (Tick all that apply)', responding with one of three options: 'I've used this', 'I've not used this' or 'Not applicable to my research'.

Subsequently, respondents are asked, 'What would help you to use more Open Research practices?' and can select up to five statements from a total of 15. In total, 13 of these statements align to the COM-B model of behaviour change [77], specifically: psychological capability (three options): 'More information on open research practices', 'More training using open research practices' and 'Understanding ethical issues (e.g. issues around data sharing)'; physical opportunity (four options): 'Supporting infrastructure (e.g. sufficient storage for open data)', 'More time', 'Workload dedicated to open research' and 'Dedicated funding for open research';

<sup>2</sup>After receiving reviewer comments on the original BORS [70], and through discussion with international collaborators, we made a number of minor changes to the current survey to ensure that all terminology would be understood across countries and languages. These changes are reported in the preregistration (<https://osf.io/njt3>).

| Open Research Practice<br>(Definition)                                                                                                                                                                        | I'm aware<br>of this | I've used<br>this | I've not<br>used this | N/A to my<br>research |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-------------------|-----------------------|-----------------------|
| <b>Open Research</b><br>(Sometimes referred to as Open Scholarship or, in a more narrow application, Open Science. Research that is conducted in a manner that is transparent and openly available to others) | ✓                    | ✓                 |                       |                       |
| <b>Study Preregistration</b><br>(E.g. pre-analysis plan, prospective registration)                                                                                                                            | ✓                    | ✓                 |                       |                       |
| <b>Registered Reports</b><br>(A format of empirical article where a study proposal is renewed before the research is undertaken)                                                                              | ✓                    |                   | ✓                     |                       |
| <b>Open Materials</b><br>(Making research materials publicly available e.g. experiments, questionnaires, intervention materials)                                                                              |                      |                   |                       |                       |
| <b>Open Data</b><br>(Making research data publicly available, e.g. FAIR data)                                                                                                                                 | ✓                    | ✓                 |                       |                       |
| <b>Open Code</b><br>(Making analysis code publicly available)                                                                                                                                                 |                      |                   |                       |                       |
| <b>Preprints</b><br>(Making research papers available prior to journal peer-review in an online repository)                                                                                                   | ✓                    | ✓                 |                       |                       |
| <b>Open Peer Review</b><br>(Journal or grant peer review where authors and reviewers are aware of each other's identity)                                                                                      |                      |                   |                       |                       |
| <b>Open Access Publication</b><br>(Making peer-reviewed papers or other publications publicly available)                                                                                                      | ✓                    | ✓                 |                       |                       |
| <b>Replication Studies</b><br>(Research attempting to reproduce the methods and findings of prior research)                                                                                                   | ✓                    |                   | ✓                     |                       |
| <b>Research Co-production</b><br>(Researchers, public and practitioners working together in research, sharing responsibility throughout a project)                                                            |                      |                   |                       |                       |

**Figure 3.** Schematic of BORS survey with example responses. If respondents selected 'I'm aware of this', they were shown the options 'I've used this', 'I've not used this' and 'N/A [not applicable] to my research'.

social opportunity (four options): 'Incentives from funders, institutions or other regulators', 'Recognition of open research in promotion and recruitment criteria', 'Support from senior researchers (e.g. supervisors and principal investigators)' and 'Support from junior researchers (e.g. PhD students, early career researchers)'; and reflective motivation (two options): 'Need for more positive opinions about open research' and 'I do not plan to take up open research practices'. Two additional options allow respondents to select 'Nothing' or 'Something else', with the latter permitting an open-ended response.

Lastly, respondents are asked demographic questions about their discipline, research methodology, career stage, and involvement in a research group and open research initiatives. Discipline categories were selected from the Higher Education Statistics Agency's Common Aggregation Hierarchy, Level 1 [83]. An open-ended textbox was included at the end of the survey which asked respondents, 'Do you have any other comments?'.

## 4.2. Data analysis strategy

### 4.2.1. Data exclusions

A total of 4175 respondents were initially recruited. In line with our preregistered exclusion criteria, 1158 were excluded owing to having incomplete data that suggested they exited the survey early or withdrew their consent ( $n = 995$ ), did not meet the career stage inclusion criteria (e.g. MSc students;  $n = 97$ ), stated that they did not consent to take part after reading the information sheet ( $n = 57$ ), indicated a 'test'

response ( $n = 5$ , for the translated surveys) or were identified as careless responders ( $n = 4$ , nonsensical open-ended responses). The final sample comprised 3017 respondents.

## 4.2.2. Main analysis

We preregistered an exploratory descriptive approach for this study. All analyses were performed in JASP [85], and descriptives are reported as percentages. Where a respondent did not tick 'I am aware of this', data were coded as 'I'm not aware of this'. In accordance with Norris et al. [53], we first report percentage awareness and use for the entire sample. This analysis is then reported by respondents' world region, research discipline, methodology, career stage, research group membership ('Yes', 'No') and involvement in an open research initiative ('Yes', 'No'). We provide key comparisons in text and refer readers to the figures. For brevity, we do not report analyses for disciplines or career stages with <50 respondents, but provide all data under a CC-BY-ND 4.0 licence for secondary data analyses (<https://osf.io/njt37/>). We then rank the COM-B statements on support for open research ('What would help you to use more Open Research practices?'), reporting percentages for the entire sample.

The questions, 'What would help you to use more Open Research practices?' and 'Do you have any other comments?' offered an opportunity for respondents to provide open-ended responses. We performed qualitative content analyses on each to determine the presence of words, themes or concepts [86] that mapped onto the 13 COM-B statements, following best practice guidance [87]. A guidebook was developed to assist in coding: two researchers (C.R.P. and E.N.) coded the data, inter-rater reliability was assessed (see §5.7), and any discrepancies were discussed between these two researchers, with help from a third (K.C.) to form consensus. Coder discrepancies occurred most frequently for responses that were deemed miscellaneous (did not map onto a specific COM-B statement) or where one coder suggested that a new theme should be developed. It is important to note that some responses were expansive and mapped onto several of the COM-B statements. In the following results, quotes are reported verbatim with ellipsis to denote where words have been omitted for length, and any identifiable information replaced with 'REDACTED'.

# 5. Results

## 5.1. Awareness and use of open research

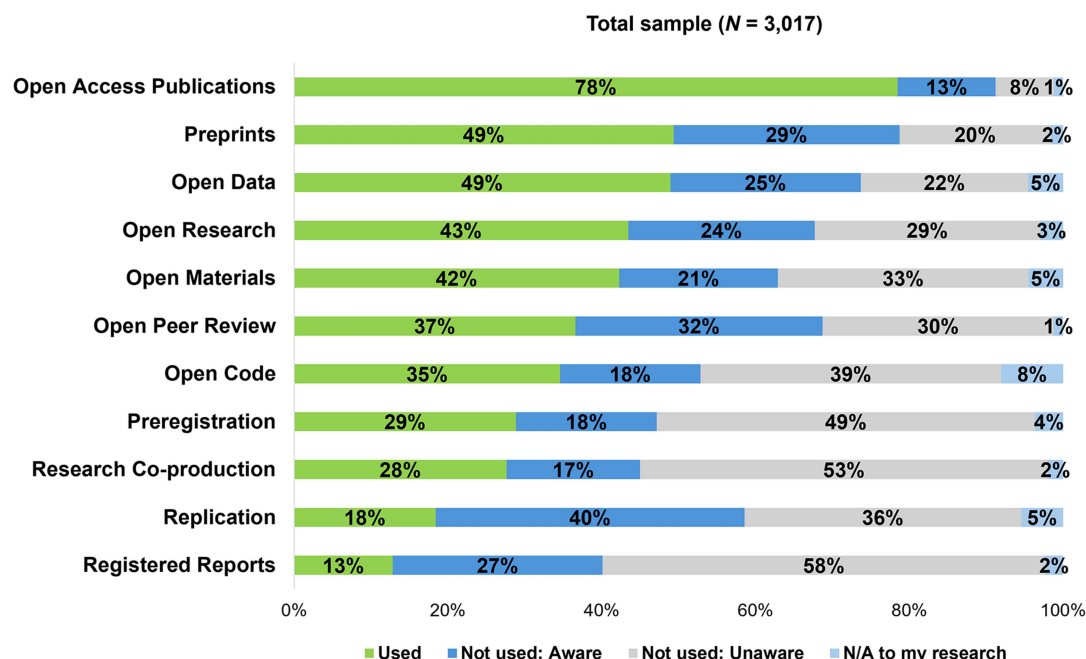
Across the sample, respondents were predominantly aware of OA Publications (92%) and Preprints (80%), and awareness only fell below 50% for Research Co-production (47%) and Registered Reports (42%). The most used practice was OA Publications (78%), and no other practices reached >50% (figure 4). This gap between awareness and use is not explained by respondents perceiving these practices not applicable to their research: across all practices, less than 8% of respondents selected this response.

## 5.2. By region

We made the decision to group countries into the world regions of Europe ( $n = 2339$ , 78%), South and North America ( $n = 369$ , 12%), Oceania ( $n = 176$ , 6%), Asia ( $n = 80$ , 3%) and Africa ( $n = 42$ , 1%) to increase their sample sizes, informed by Our World in Data and the United Nations (<https://ourworldindata.org/world-region-map-definitions>).<sup>3</sup>

Across regions, respondents were predominantly aware of OA Publications, with awareness highest in Asia (96%) and lowest in Africa (76%). Respondents from Asia reported the most uniform awareness across all open practices (>50%). For respondents from Europe, awareness was below 50% for Research Co-production (44%) and Registered Reports (43%); in North and South America for Open Code (49%),

<sup>3</sup>Our World in Data defines six world regions: Europe, North America, South America, Oceania, Asia and Africa. However, we then combined North and South America due to the small sample size in the former, which aligns with the United Nations who define five world regions: Europe, North and South America, Oceania, Asia and Africa. We recognize therefore that there are several ways to define world regions, and we took a data-driven approach in the current study to increase subsample sizes. Our data are openly available for anyone who wishes to look at the regional or country-level data. Countries included in Europe: Italy, UK, Austria, Slovakia, Norway, Germany, Finland, Croatia, Sweden, Switzerland, The Netherlands, Belgium, Ireland, Serbia, Czech Republic, Denmark, France, Portugal, Romania, Estonia, Greece, Hungary, Balkans and Spain; in North and South America: United States, Canada, Brazil, Argentina, Chile and Colombia; in Asia: Japan, China, South Korea, India, Indonesia, Turkey, Iran, Hong Kong and UAE; in Africa: South Africa, Tanzania, Nigeria and Sudan; and in Oceania: Australia and New Zealand.



**Figure 4.** Percentage awareness and use of open research practices. For each practice, where a respondent stated, 'I'm aware of this', they were then able to choose from 'I've used this', 'I've not used this' or 'Not applicable [N/A] to my research'. For this reason, the percentage awareness in all figures is the sum of 'Used' (light green), 'Not used: Aware' (dark blue) and 'Not applicable [N/A] to my research' (light blue). Percentages for 'Used' are shown in light green.

Preregistration (44%) and Registered Reports (38%); in Africa for Replication (45%), Open Code (45%), Registered Reports (33%) and Preregistration (26%); and in Oceania for Registered Reports (35%).

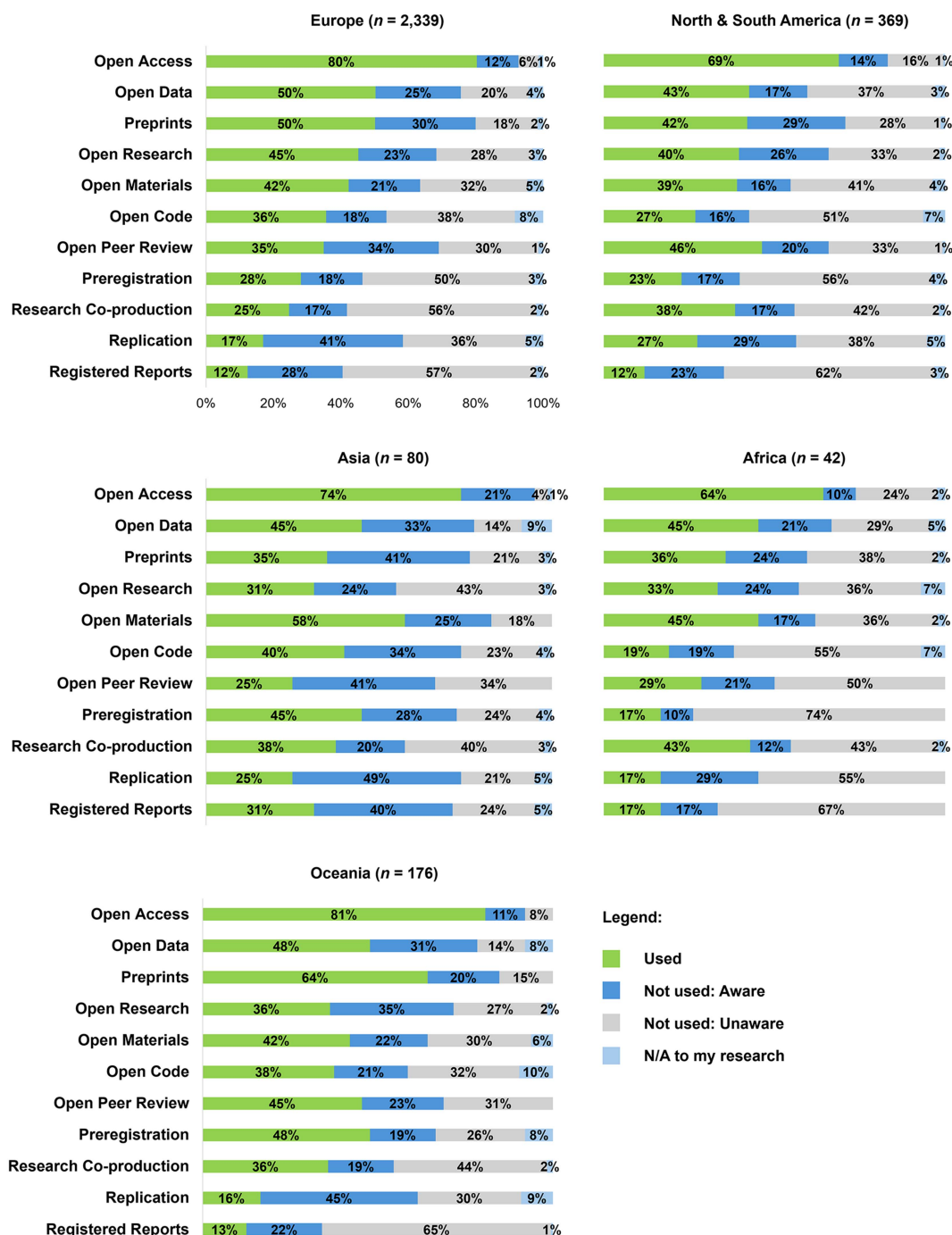
Use of OA Publications was the most used practice across regions, highest in Oceania (81%) and lowest in Africa (64%). Respondents from Europe reported the most uniform usage across all practices. After OA Publications, respondents from Europe used the practices of Open Data and Preprints the most (both 50%); Asia used Open Materials (58%) the most but showed the greatest awareness–use gap across practices; Africa used Open Data and Open Materials the most (both 58%) and Oceania used Preprints the most (64%). Use fell below 50% for the remaining practices (figure 5).

### 5.3. Research discipline

Estimates of awareness and use only surpassed those of OA Publications for Preprints in Mathematical Sciences (96% awareness; 86% use) and Open Code in Computing (89% awareness; 72% use).

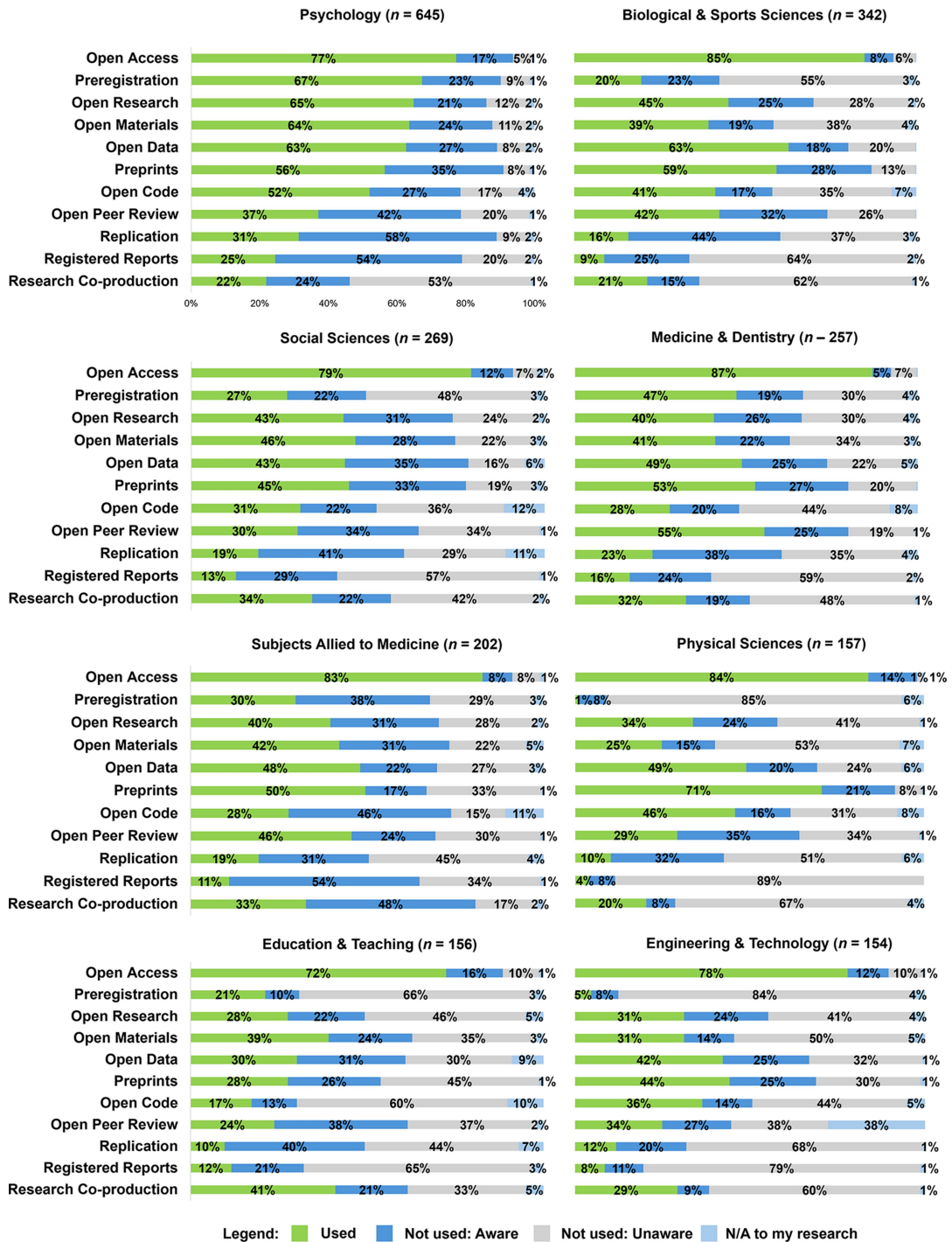
Psychology showed the highest awareness of Preregistration (91%), Open Research ([term] 88%), Open Materials (89%), Open Data (92%), Replication (91%) and Registered Reports (80%). However, awareness of Preprints was highest in mathematical sciences (96%); Open Code in computing (89%); Open Peer Review in medicine and dentistry (81%) and Research Co-production in education and teaching (67%). Awareness fell below 50% for the following disciplines and practices: Preregistration in the physical sciences (15%) and humanities and liberal arts (9%); Open Materials in the physical sciences, mathematical sciences (both 47%), and general and others in sciences (43%); Open Code in agriculture, food and related studies (38%) and humanities and liberal arts (19%); Replication in engineering and technology (32%) and humanities and liberal arts (31%); Registered Reports in subjects allied to medicine (46%), humanities and liberal arts, mathematical sciences (both 19%) and the physical sciences (11%); and Research Co-production in the physical sciences (33%) and mathematical sciences (22%).

Psychology demonstrated the greatest uniformity in use, with only Open Peer Review (37%), Replication (31%), Registered Reports (25%) and Research Co-production (22%) below 50%. Biological and sports sciences reported high use of Open Data (63%) and Preprints (59%); medicine and dentistry—Open Peer Review (55%) and Preprints (53%); physical sciences—Preprints (71%); mathematical sciences—Preprints (86%) and Open Code (53%); geographical and environmental studies—Open Data (69%) and the term Open Research (52%); and computing—Open Code (72%), Preprints (61%) and Open Data



**Figure 5.** Awareness and use of open research practices by respondents' region. For all descriptive figures herein, the order of open research practices follows the ranking of 'Use' (light green) for the first category (e.g. Europe for figure 5).

(58%). All other practices fell below 50%. Overall, use of Preregistration was the lowest for physical sciences and humanities and liberal arts (both 1%); Open Research for education and teaching (28%) and mathematical sciences (25%); Open Materials for general and others in sciences (22%) and mathematical sciences (19%); Open Data for humanities and liberal arts, education and teaching (both 30%), and business and management (28%); Preprints for education and teaching (28%) and humanities and liberal arts (19%); Open Code for education and teaching (17%) and humanities and liberal arts (2%); Open Peer Review for mathematical sciences (21%) and business and management (20%); Replication for physical sciences, education and teaching (10%) and humanities and liberal arts (6%); Registered Reports for



**Figure 6.** Awareness and use of open research practices by discipline.

physical sciences and mathematical sciences (4%); and Research Co-production for physical sciences, general and others in sciences (both 20%) and mathematical sciences (11%; [figure 6](#)).

## 5.4. Methodology

Respondents using quantitative methodology reported the most uniform awareness across all practices (>50%, except for Research Co-production). Respondents using qualitative methodology reported high awareness of Preprints (63%) and Open Data (59%), but awareness was below 50% for Research Co-production (49%), Replication (42%), Open Code (31%), Preregistration (26%) and Registered Reports

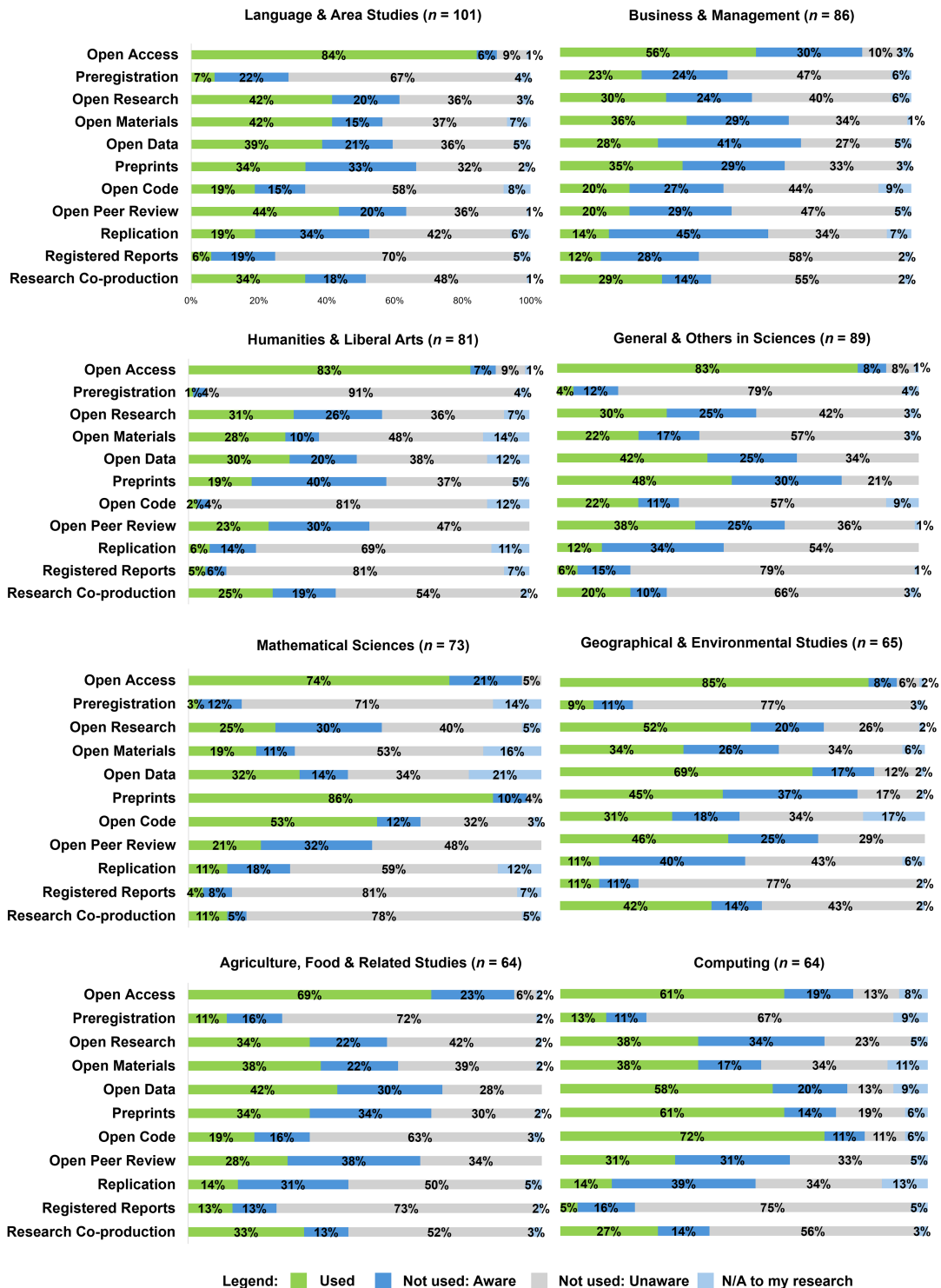
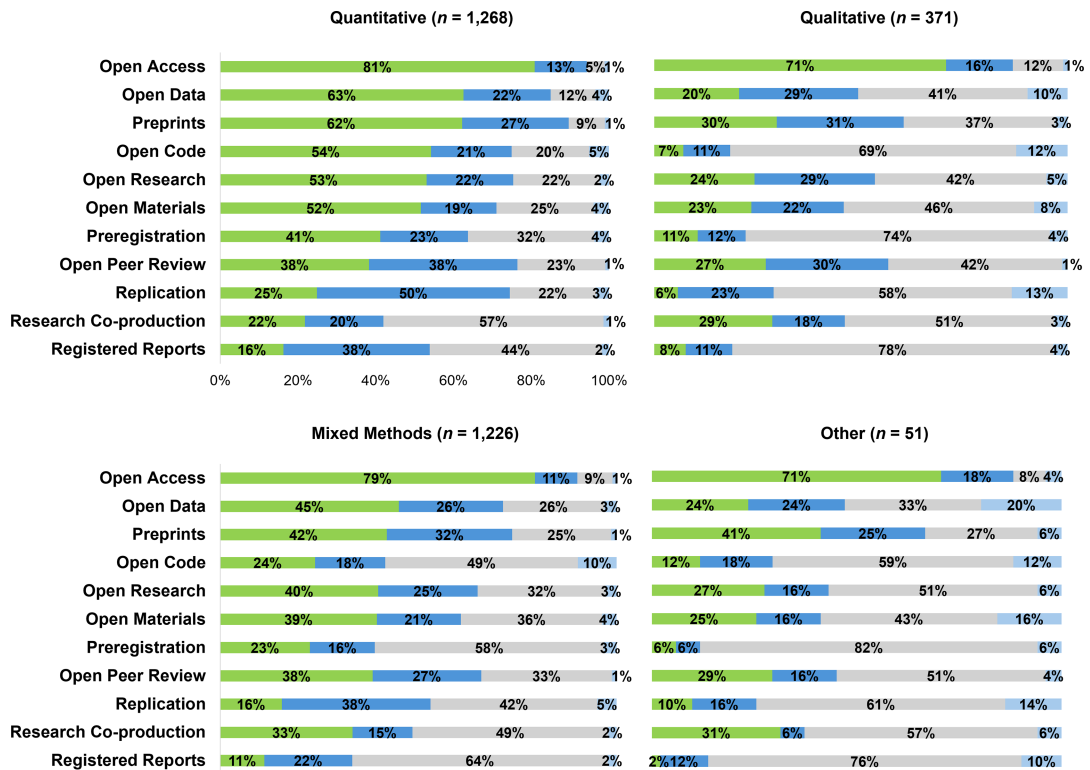


Figure 6. (Continued.)

(22%). Respondents using mixed methods reported high awareness of Preprints (75%) and Open Data (74%), but awareness was below 50% for Preregistration (42%) and Registered Reports (36%). Respondents using 'other' methodologies (e.g. theoretical and algorithmic; machine learning / AI) reported high awareness of Preprints (73%) and Open Data (67%), but awareness was below 50% for Open Peer Review (49%), Open Research (49%), Research Co-production (43%), Open Code (41%), Replication (39%), Registered Reports (24%) and Preregistration (18%).



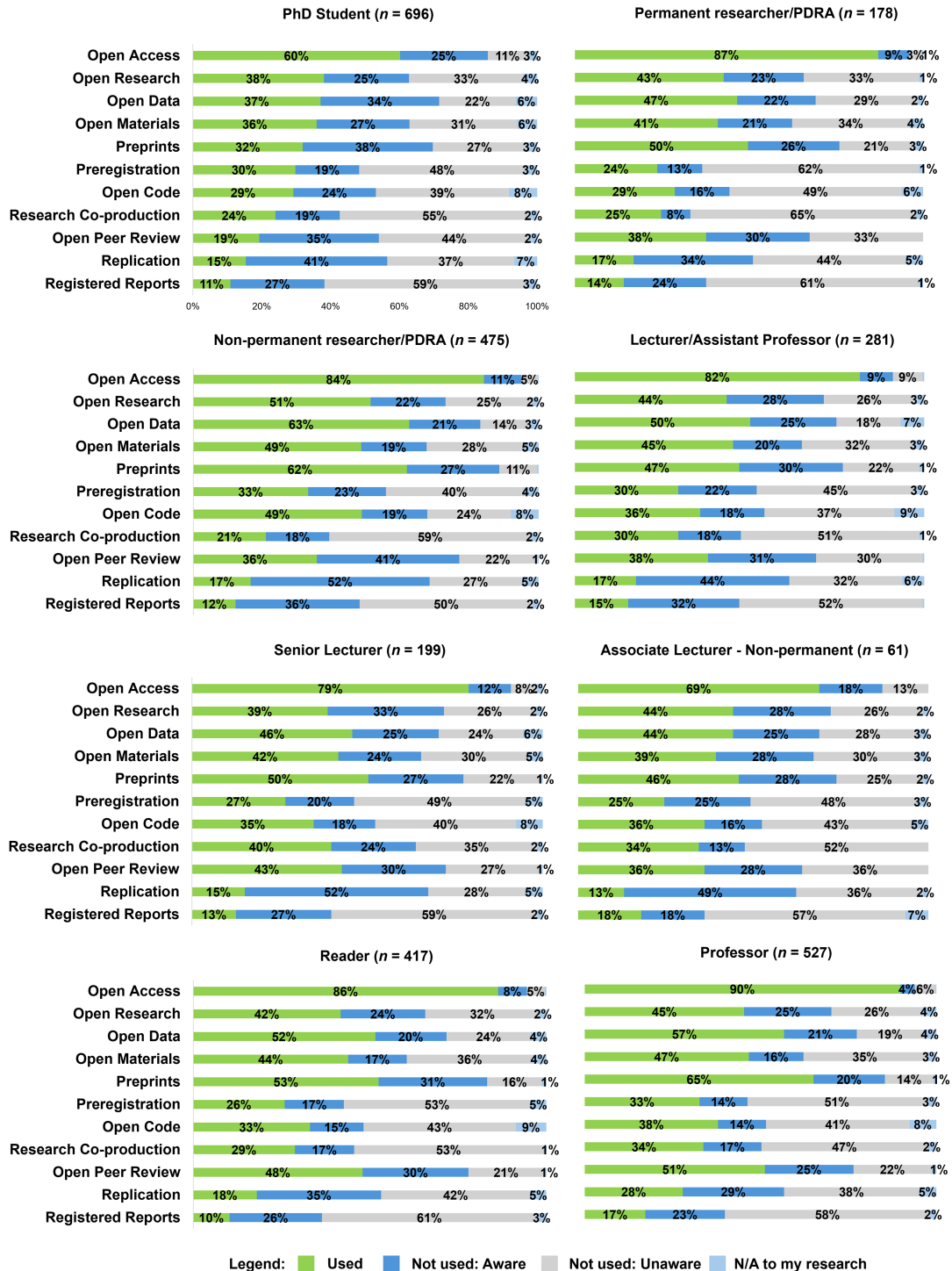
**Figure 7.** Awareness and use of open research practices by methodology.

Respondents using quantitative methodology also reported the highest uniform use of open research practices, with all reaching >50% except for Preregistration (41%), Open Peer Review (38%), Replication (25%), Research Co-production (22%) and Registered Reports (16%). Except for OA Publications, use of all other open research practices fell below 50% for respondents using qualitative, mixed methods or 'other' methodology. Respondents using qualitative methodology least used Open Code (7%) and Replication (6%). Respondents using mixed methods least used Replication (16%) and Registered Reports (11%; figure 7).

## 5.5. Career stage

Across all career stages, respondents were predominantly aware of OA Publications. Awareness of certain open research practices was below 50% for the following career stages: PhD students—Research Co-production (45%) and Registered Reports (41%); permanent postdoctoral research assistants (PDRAs)—Registered Reports (39%), Preregistration (38%) and Research Co-production (35%); non-permanent PDRAs—Research Co-production (41%); associate lecturers (non-permanent)—Research Co-production (48%) and Registered Reports (43%); lecturers—Research Co-production (49%) and Registered Reports (48%); senior lecturers—Registered Reports (41%); readers—Research Co-production (47%), Preregistration (47%) and Registered Reports (39%); and professors—Preregistration (49%) and Registered Reports (42%).

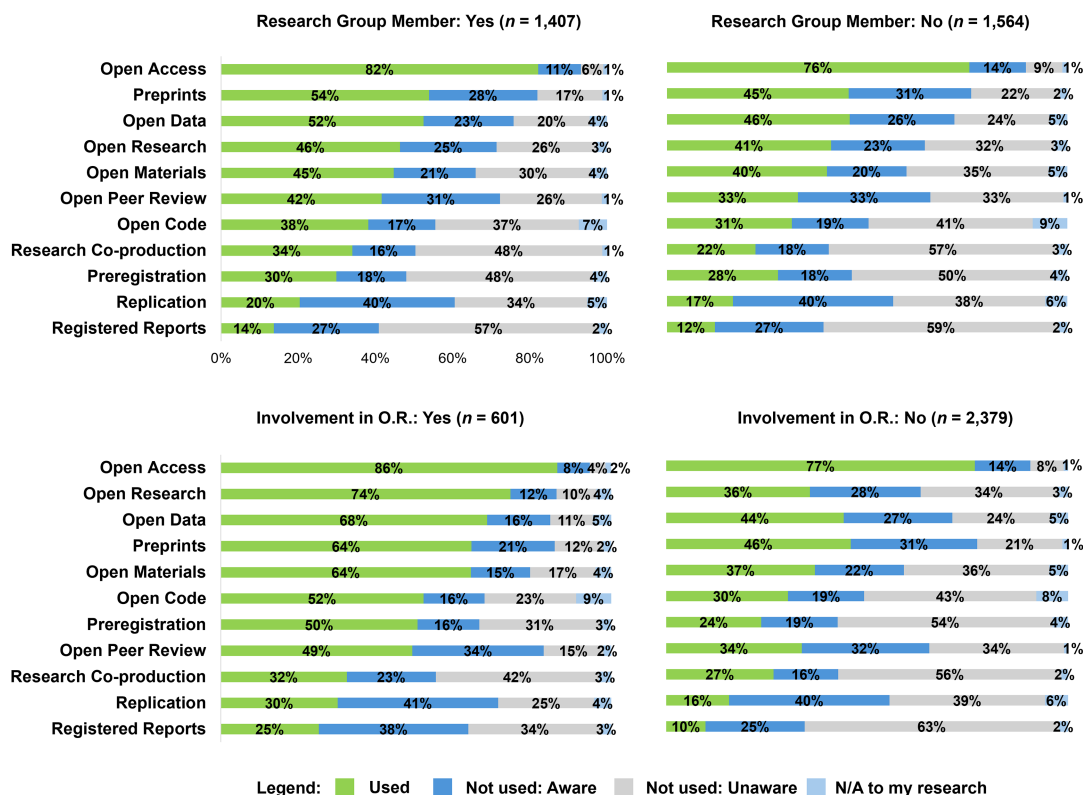
OA Publications was the most widely used practice across career stages, with professors using this the most (90%) and PhD students using this the least (60%). For both PhD students and associate lecturers, use of the remaining open research practices dropped below 50%, with both groups using Replication (16%, 13%) and Registered Reports the least (11%, 18%). Permanent PDRAs and senior lecturers reported high use of Preprints (both 50%); non-permanent PDRAs—Open Data (63%), Preprints (62%) and Open Research (51%); lecturers—Open Data (50%); and both readers and professors reported high use of Preprints (53% and 65%) and Open Data (52% and 57%, respectively). All other practices across career stages fell below 50% (figure 8).



**Figure 8.** Awareness and use of open research practices by career stage, ordered from early to senior career stage.

## 5.6. Involvement in research group or open research initiative

Respondents involved in a research group reported slightly higher awareness and use of open research practices than those not involved. Respondents involved in an open research initiative reported substantially higher awareness and use of open research practices; use is at or above 50% for all practices except Research Co-production, Replication and Registered Reports, whereas OA Publications is the only practice that reaches >50% use for those not involved (figure 9).



**Figure 9.** Awareness and use of open research practices by research group ('Yes', 'No') and involvement in an open research initiative (e.g. ReproducibiliTEA journal clubs, 'Yes', 'No'<sup>4</sup>). The left panel for each is sorted from the highest to lowest percentage use of the 11 open research practices. O.R. = open research.

## 5.7. Support for open research practices

The ranked COM-B statements, pertaining to the strategies that would support respondents to use more open research practices, are shown in table 2.

Additional (optional) open-ended responses were provided by 156 (5.17%) respondents. These were categorized into the COM-B statements with substantial inter-rater reliability between the two coders (Cohen's  $\kappa = 0.78$ , 95% CI 0.71–0.85). Overall, 10 out of the 13 COM-B statements were supported by the data (table 3). The three that were not supported were: 'Support from junior researchers' (social opportunity), 'Support from senior researchers' (social opportunity) and 'I do not plan to take up open research practices' (reflective motivation). Some respondents discussed how they were already adopting open research initiatives with these responses categorized as 'Nothing' (no support needed).

Five additional statements were developed, resulting in a total of 15 displayed in table 3. The first was 'Rules and regulations' which we categorized as physical opportunity. This focused mainly on open research practices becoming a mandatory requirement by journals, publishers, and funders. The second was 'Not a 'one size fits all' approach' categorized as reflective motivation. This highlighted how certain open research practices may not be applicable or appropriate across all research disciplines (e.g. the arts), epistemologies (e.g. concepts of replication and reproducibility), and methodologies (e.g. replication in

<sup>4</sup>It may be questioned why 10% of respondents who stated they were involved in an open research initiative did not select 'I'm aware of this' for the term open research. We offer a few explanations for this: first, analysis of the raw data suggests that many of these respondents came from countries who do not have an equivalent term for 'open research' in their native language (see our preregistration for this note: <https://osf.io/2ewz6/files/tkf47>); second, some open-ended responses suggested that these respondents were part of an 'open access' initiative or were library staff; third, for the question about being involved in an initiative, we gave an example of the 'ReproducibiliTEA journal club' as an example; respondents may have been part of such initiative(s) but not heard of the term 'open research'; fourth, some of these respondents may have perceived that being involved in this survey meant that they were involved in such an initiative (e.g. one respondent stated, 'Congratulations on this initiative' in their open-ended response after this question). As such, this may reflect familiarity with the term 'open research', which we reflect upon in our Limitations. There are no indications from the raw data that these represent careless responders, so they are retained in the analyses. In other analyses, these respondents represent only approximately 2% of the data.

**Table 2.** Ranked COM-B statements ( $n = 3017$ ). Respondents were asked to select up to 5.

| Statement                                                          | Rank | %    | COM-B category           |
|--------------------------------------------------------------------|------|------|--------------------------|
| Incentives from funders, institutions or other regulators          | 1    | 52%  | Social opportunity       |
| Dedicated funding for open research                                | 2    | 47%  | Physical opportunity     |
| Recognition of open research in promotion and recruitment criteria | 3    | 42%  | Social opportunity       |
| More training using open research practices                        | 4    | 42%  | Psychological capability |
| More information on open research                                  | 5    | 40%  | Psychological capability |
| More time                                                          | 6    | 35%  | Physical opportunity     |
| Supporting infrastructure                                          | 7    | 33%  | Physical opportunity     |
| Understanding ethical issues                                       | 8    | 31%  | Psychological capability |
| Support from senior researchers                                    | 9    | 28%  | Social opportunity       |
| Workload dedicated to open research                                | 10   | 26%  | Physical opportunity     |
| Need for more positive opinions about open research                | 11   | 13%  | Reflective motivation    |
| Support from junior researchers                                    | 12   | 10%  | Social opportunity       |
| I do not plan to take up using open research practices             | 13   | 1.9% | Reflective motivation    |
| Nothing                                                            | 14   | 1.8% | n/a                      |

qualitative research) with calls for more nuanced, contextual, and considerate perspectives. The third was *'Alternative publishing models'* categorized as physical opportunity. Here, numerous responses centred on moving away from for-profit journals, reducing the cost of OA publishing, and supporting Diamond OA. The fourth theme was *'Consideration of the challenges in conducting open research'* which was categorized as reflective motivation. This highlighted the need for more information around how to share sensitive, qualitative data and potential barriers such as data misuse or plagiarism, inequalities between countries, and disciplinary nuances regarding how to protect future patents and/or commercial products. The fifth theme was *'A need for culture change'* categorized as social opportunity. This focused on changing current evaluation frameworks and incentive structures to ensure that open research benefitted one's career. It also highlighted pressures of temporary contracts and uncertain career paths and the hyper-focus on publications as 'career currency'.

Additional (optional) free text comments were provided by 170 respondents (5.6%) at the end of the survey. These were again categorized into the 15 statements identified above. Here, a sub-theme emerged from the COM-B statement, *'More training using open research practices'* that recognized the need to embed open research earlier in the taught curriculum. For example, one respondent stated, *'In [my] Masters Degree, Open Research was not discussed and taught [...]. Ensuring it's covered in research modules is essential to uptake'*. Furthermore, one additional theme was identified: *'Positive views on open research; already or planning to use'*. This theme can be categorized as reflective motivation, with respondents discussing several initiatives they are involved in, and practices they have adopted. This theme had a sub-theme of *'more than just practices'*, with one respondent expressing how open research can be used to challenge the very structure of academia to improve diversity, inclusion, equality and representativeness.

## 6. Discussion

This mixed methods study assessed awareness and use of open research in a large sample of international researchers across disciplines and methodologies. Findings indicate high awareness of most open

**Table 3.** Content analysis of open-ended responses to the question, ‘What would help you to use more Open Research practices?’. A total of 10 COM-B statements were supported, and five additional statements were developed.

|                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>More information on open research practices (psychological capability)</b>                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                            |
| ‘I need to understand what open research is and how it works’                                                                                                                                                                                                                                                                                                                                                       | ‘Readily available and easy to understand information on how to conduct/use open research practices’                                                                                                                                                         | ‘It would be helpful to learn a bit more about the reasons that lead to the assumption that open science contributes to well done science’                                                                                 |
| <b>More training using open research practices (psychological capability)</b>                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                            |
| ‘I find the Open Science website complicated and tricky to navigate. It took me ages to figure out how to do a really simple pre-registration, such that as I prepare to do more experiments, I am really dreading filling in the forms again’                                                                                                                                                                      | ‘Being taught about it from an early research point. As a PhD student I was never taught anything else about research. You are left to figure all this out on your own’                                                                                      | ‘Better implementation of open science practices in teaching, thus that young researchers learn it from the start and establish routines, before they work with me’                                                        |
| <b>Understanding ethical issues (psychological capability)</b>                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                            |
| ‘In many countries, including [REDACTED], sharing raw data is not legal. In general, open science needs to be supported by the law, first and foremost by EU law so that the various member states can transpose the relevant EU directives. This is important because sometimes one thing is permitted in one country, but not in another (or we may simply do not know if the other country permits it or not...’ | ‘Clearer guidelines on how to handle qualitative data in open research practices, discussion of how to handle making study data publicly available if participants’ information and consent form did NOT detail that raw or cleaned data would be published’ | ‘More information on how to protect the data being made available from misuse and plagiarism (this sometimes discourages people from making data and research results available)’                                          |
| <b>Supporting infrastructure (physical opportunity)</b>                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                            |
| ‘(large) data and code sharing infrastructure I can easily share with researchers not in my institution’                                                                                                                                                                                                                                                                                                            | ‘Devoted and trained staff to support us, e.g. (open science) data manager’                                                                                                                                                                                  | ‘I am a huge fan of using open data, the main difficulty I have encountered is storage limits: many of the raw data sets we use (e.g. microscopy) have very large file sizes which are beyond open data storage limits...’ |
| (Continued.)                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                            |

Table 3. (Continued.)

|                                                                                                                                                                                                                           |                                                                                                                                                                                                                                  |                                                                                                                                                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>More time (physical opportunity)</b>                                                                                                                                                                                   |                                                                                                                                                                                                                                  |                                                                                                                                                                                                               |
| 'The key thing is to have more time: with excessive workloads it is difficult to learn new skills or have time to consider how to apply them (e.g. for registered reports or pre-registration, which I would love to do)' | 'The burden on people taking up open science is high, and it may take longer than the normal submission process. The system related to open research should be changed to one that is simple and quick to handle than it is now' | 'I do not have time to follow all the things related to publication. When a paper is accepted for me it is fine'                                                                                              |
| <b>Workload dedicated to open research (physical opportunity)</b>                                                                                                                                                         |                                                                                                                                                                                                                                  |                                                                                                                                                                                                               |
| 'Open research is currently forced on researchers by some funding institutions but not always paid for, it requires time, effort and funding. ... this way I consider it mainly a nuisance'                               | 'Any kind of consideration in the departmental workload to support the time needed for open research practices'                                                                                                                  | 'The time dedicated to open stuffs is time subtracted to the next research or teaching activity, so it will not advance science but slow it if becomes too demanding in terms of data and other requirements' |
| <b>Dedicated funding for open research (physical opportunity)</b>                                                                                                                                                         |                                                                                                                                                                                                                                  |                                                                                                                                                                                                               |
| 'We really need academic publishers to fund an online database of replications to off-set the publishing bias towards significant results (often still presented without effect size details)'                            | 'Money to cover the costs, e.g. research assistance to prepare datasets for sharing, or money to make publications OA if collaborating with people in the Global South'                                                          | 'More funding for open science initiatives and academic institutions who implement open science practices'                                                                                                    |
| <b>Incentives from funders, institutions or other regulators (social opportunity)</b>                                                                                                                                     |                                                                                                                                                                                                                                  |                                                                                                                                                                                                               |
| 'Journals supporting open research practice, [...] better if journals can have a standardized or similar format to avoid large amount of edits, templates and examples'                                                   | 'Work with research associations and journal editors to promote open science as a professional standard'                                                                                                                         | 'Inclusion of criteria that promote and fund Open Science in calls for proposals from all research funding agencies'                                                                                          |
| <b>Recognition of open research in promotion and recruitment criteria (social opportunity)</b>                                                                                                                            |                                                                                                                                                                                                                                  |                                                                                                                                                                                                               |
| 'Open research should receive a higher score in the recruitment process or career progressions'                                                                                                                           | 'A simple and powerful incentive would be for universities to prioritise academics who follow open research practices for research and teaching positions'                                                                       | 'That my career would not depend on how much I publish'                                                                                                                                                       |
| (Continued.)                                                                                                                                                                                                              |                                                                                                                                                                                                                                  |                                                                                                                                                                                                               |

Table 3. (Continued.)

|                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Need for more positive opinions about open research (reflective motivation)</b>                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 'Success stories from Open research practices that clearly illustrate the positive outcome of committing to these practices'                                                                                                                                                                                                                                                     | 'Acknowledgement for PhD theses—e.g. replication is valuable but I'd never do it because my contract expires and it would waste my time because I cannot use it in my thesis'                                                                                                                                                                                                                                                                                                            |
| <b>Additional statements developed:</b>                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Rules and regulations (physical opportunity)</b>                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 'Enforcement of open research practices by journals. For example, many journals require a "data available upon reasonable request" statement in published articles, but when I've emailed the author asking for data [...] the data is not available'                                                                                                                            | 'That open science would be the rule for ALL, not an occasional practice [sic] endorsed by some researchers but not others'                                                                                                                                                                                                                                                                                                                                                              |
| <b>Not a 'one size fits all approach (reflective motivation)</b>                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 'More kindness/consideration among researchers for when/which open research practices make sense when devising systemic incentive structures, i.e. taking into account different epistemologies and disciplines'                                                                                                                                                                 | 'The assumption that open science approaches are applicable to or necessary for all types of research is problematic. In my case, the ontological aims of open science are incompatible with qualitative methodologies'                                                                                                                                                                                                                                                                  |
| <b>Alternative publishing models (physical opportunity)</b>                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 'Diamond Access—currently many researchers see OS as article fees, which OS is not. Also, we need more justice (for example: how is price for an OA fee estimated and can authors all over the world pay for that, and why would we support publishing companies as content providers either as authors/reviewers/ editors). OS needs another scientific publication model [...] | 'A change in the publishing system to move from for-profit journals with few journal editors setting up enormous open-access prices to Diamond open-access practices such as Peer Community In is offering'<br>The universities and the scientific societies should promote and publish themselves open access journals with no fee for authors and readers, it makes no sense nowadays that a big amount of money is being spent for open access publications of commercial publishers' |
| (Continued.)                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

Table 3. (Continued.)

| Consideration of the challenges in conducting O.R. (reflective motivation)                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'There is also the problem of present or future patent'                                                                                                                                                                                                                                                                                         | 'More information on how to protect the data being made available from misuse and plagiarism (this sometimes discourages people from making data and research results available)'                                                                                                                                             | 'It has always seemed to me that the practice favors wealthier countries, leaving peripheral countries with the adaptation of large databases, which can be accessed by others'                                                                                                                                                                                                                                                                                                           |
| A need for culture change (social opportunity)                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 'A healthier researcher evaluation framework, were scientific worth is not heavily related to where you publish and how often. Otherwise, having an already strenuous and uncertain career path as is, there is no pragmatic incentive to make the resources to produce/continue similar scientific outcomes (say code, e.g.) openly available' | 'It is necessary to change the institutional mentality and requirements. We are all being asked to participate in exploitative publishing, to chase high impact factors, etc., while open access and free access to articles are increasingly seen as a bonus, as something that is 'nice' if possible, but not so important' | 'In short I believe that open science is good [sic] for science advancement but without structural changes in the working situation of scientist, it will be always represent a threat in the perspective of a scientific career. Working in the academy in [REDACTED] means precariousness, and this is almost true in every country in Europe. The actual problem of "open science" is that on one hand is good for science, but on the other hand is bad for scientists' career [sic]' |

The table contains example quotes. Additional quotes can be found in the supplementary material, and all (anonymized) open-ended responses can be found in the open data: <https://osf.io/njt37>.

research practices, except for Research Co-production and Registered Reports. Use was substantially lower, however, with only OA Publications reaching >50%. Awareness therefore does not always translate into use, consistent with prior work [50,52,53]. Variations across regions, disciplines, methodologies, career stages and qualitative accounts provide some explanations for this awareness–use gap.

Respondents from the regions of Europe, North and South America, Africa and Oceania reported high awareness and use of OA Publications (>60%). Respondents from Asia reported the most uniform awareness of all open research practices (>50%), but the highest awareness–use gap, and respondents from Europe reported the most uniform use. Awareness of Registered Reports was uniformly low across Europe, North and South America, Africa and Oceania, while other practices showed region-specific gaps (e.g. Research Co-production in Europe; Open Code and Preregistration in the Americas; Replication and Open Code in Africa). After OA Publications, respondents from Europe reported high use of Preprints and Open Data; Asia used Open Materials and Oceania used Preprints. While we remain tentative in making any generalizations owing to the low sample sizes in some regions, these variations may highlight region-specific barriers to adoption. This aligns with recent commentaries that outline how the adoption of open research practices will be influenced by supporting infrastructure, education, the strength of regional policies and priorities, the representation of researchers in the publishing and funding landscape, language and platform accessibility, and wider regional research cultures [56,59]. A recent review shows that the majority of procedural, community and structural-based initiatives in open research come from developed regions [37]. For open research to be a global enterprise, these barriers to participation need to be explicitly acknowledged and solutions sought.

Our data also reveal disciplinary variations in open research practices. Again, high awareness and use of OA Publications were seen across disciplines, but use varied substantially: the highest reported by respondents from medicine and dentistry and the lowest reported by business and management. Despite having equal awareness and use of OA Publications compared to other disciplines, respondents from mathematical sciences and computing were more aware of Preprints and Open Code within their own disciplines, respectively. Respondents from psychology showed the highest uniform awareness and use of open research practices, with the strongest uptake of Preregistration. This likely reflects this field's reckoning with their widely popularized 'replication/reproducibility crisis' [16,88,89] as well as a sustained focus on Preregistration [21]. This analysis revealed that certain practices appear to be discipline-specific: those with strong quantitative traditions and established open infrastructures showed higher use of Preprints (e.g. physical sciences, mathematical sciences, medicine and dentistry, computing and biological and sports sciences), Open Data (e.g. biological and sports sciences and computing) and Open Code (e.g. mathematical sciences and computing). Indeed, these disciplines have been using preprint servers (*ArXiv*, *BioRxiv* and *MedRxiv*) long before others (e.g. *PsyArXiv*), with these predating discussions of 'open research' [38,90]. However, respondents from the physical sciences, mathematical sciences, humanities and liberal arts and education and teaching appeared repeatedly among the lowest adopters of Preregistration, Replication and Registered Reports. Not all open research practices will be equally applicable to every discipline or research methodology; for example, Preregistration and Registered Reports are useful for disciplines where hypothesis testing is common but may be less appropriate in disciplines with a focus on exploratory research or where researcher bias is arguably less prevalent. We remain tentative in our language here, nevertheless, because it can be argued that Preregistration is applicable to exploratory research to prevent 'postdiction' once data are analysed [20,91]. Furthermore, no research is completely free of either researcher or publication bias, and Preregistration and Registered Reports provide a protective mechanism [22,92].

Turning to methodological variations, open research has been predominantly signposted in quantitative research domains, owing to concerns about researcher bias and QRPs (e.g. *p*-hacking; *HARKing*) that reduce replicability, reproducibility and transparency [7,71]. It is therefore unsurprising that quantitative researchers in this study showed the highest, and most uniform, awareness and use of open research practices. Despite this, use of Preregistration, Open Peer Review, Replication and Registered Reports fell below 50%. Potential explanations for this may be that structural and cultural incentives still predominantly recognize novelty over rigour that influence researcher behaviour, as well as the misconception that preregistration and registered reports reduce novelty, creativity and exploration [93]. In contrast, qualitative and mixed methods researchers showed markedly lower awareness of several reproducibility-oriented practices (e.g. Open Code, Preregistration and Registered Reports) and reported very low usage, with no practice other than OA Publications exceeding 50%. Recently, there have been critical discussions regarding the ontological and epistemological (in)compatibility of many open research practices for qualitative research [67,68,94,95]. Viewing open research as incompatible with one's

methodological framework has been reported as a barrier to PhD students' participation [96], and there have been calls to ensure epistemological pluralism in open research reform [68].

Across career stages, awareness was particularly low for Preregistration, Registered Reports and Research Co-production. Key variations occur in use of open research practices, with professors using OA Publications the most and PhD students the least, potentially owing to the allocation of resources and access (e.g. funding for OA from grants or institutional publishing partnerships) as well as PhD students having less opportunity to publish their work. For PhD students and non-permanent associate lecturers, use of all open research practices except for OA Publications fell below 50%, with the use of Replication and Registered Reports particularly low. This likely reflects the precarity and incentive structures faced by early career researchers, including pressure to prioritize novelty, limited access to resources and the perceived time and administrative costs of Replications and Registered Reports [22,97] (see [33,98] for debates). Professors also reported using more open research practices, except for Registered Reports. This may reflect their experience and time in the field, with Registered Reports being a relatively newer practice than others.

We further explored supportive mechanisms that may facilitate open research. Here, we found that being involved in an open research initiative was associated with greater awareness and use across all practices. Given that use of Preregistration, Registered Reports and Replication was the lowest across subsamples, involvement in an open research initiative may be an effective strategy to increase adoption. However, owing to the correlational nature of these data, it may also be the case that those who are already using open research practices will join associated initiatives. Underpinned by the COM-B model of behaviour change [77], respondents reported that the top five strategies that would support open research were incentives from funders, institutions or other regulators (*social opportunity*), dedicated funding (*physical opportunity*), recognition in promotion and recruitment criteria (*social opportunity*), more training and more information (*both psychological capability*). Indeed, there have been positive steps to incorporate open research training for both researchers and students [16,36], incentives such as badges for open research adoption [43], changes to research assessment and funding for meta-research (see [37]). Yet more work is needed to ensure that adopting open research does not create (further) inequities in the academic ecosystem. For example, it should be recognized that open research requires time and effort [62], and, therefore, a culture of *slower science*—emphasizing quality and rigour over quantity and haste—should be prioritized [99].

Turning to the qualitative data, we found that 10 out of the 13 COM-B statements were supported by respondents' perceptions of open research. Here, barriers to engagement were highlighted, clustered around the need for support (information, education and administration), clarification of ethical and legal matters (particularly for sensitive qualitative data) and reform of assessment and incentive systems (e.g. guidelines from journals/funders; promotion and hiring criteria). Additional statements were also developed and mapped onto the COM-B model. These focused on implementing rules and regulations (*physical opportunity*), alternative publishing models (*physical opportunity*), a need for culture change (*social opportunity*), conversations and consideration of the challenges in conducting open research (*reflective motivation*) and acknowledging that a 'one size fits all approach' is not always possible or appropriate (*reflective motivation*; e.g. for patents, see [65]).

## 6.1. Limitations and future directions

Our findings are limited by our sampling strategy and survey methodology. First, respondents were mainly from Europe (77%) with low representation from Asia, Africa and the Middle East. This is an important consideration because opportunities to participate in open research may not be equal; researchers in developing countries may experience greater barriers [56]. Furthermore, data from six disciplines are not reported here because there were fewer than 50 respondents. We therefore recommend this work be expanded through global consortia and big team science approaches [61].

Second, we recruited a convenience sample primarily through international reproducibility networks. As a result, researchers who are already aware of and using these practices, or hold more positive perceptions towards open research, may have been more likely to respond. This sampling approach, combined with the self-report nature of the survey, means that the observed estimates of awareness and use may be an overestimation relative to the broader research population. Our demographic data provide some partial reassurance in this regard, as more respondents reported *not* being involved in an open research initiative ( $n = 2379$ ) than involved ( $n = 601$ ), yet this does not fully resolve issues of sampling and social desirability biases.

Finally, respondents were asked whether they had used each of 11 open research practices, but this does not capture frequency of use. Consequently, estimates of use should be interpreted as indicators of 'lifetime prevalence'. Furthermore, apparent variations in awareness and use between practices may reflect respondent's familiarity with terminology or differences in how long these practices have existed. For example, the term 'Open Research' is also commonly referred to as 'Open Science' and 'Open Scholarship', and 'Research Co-production' is referred to as 'Citizen Science' and 'Crowdsourcing'. In addition, practices such as OA Publications, and in some disciplines Preprints, predate others, such as Preregistration and Registered Reports. These factors may explain why awareness and use of open research were not highest among the 11 practices measured. Ongoing efforts to develop more consistent and precise definitions of open research terms (e.g. [100]) are likely to improve both measurement and awareness over time.

An alternative methodological approach that can overcome these limitations is to assess use of open research practices directly from research outputs (e.g. [101]), which can extend to evaluations of practice usability/efficacy [102,103]. While output-based measures provide objective estimates of use, they cannot capture present engagement with certain practices (e.g. Preregistration and Research Co-production) owing to the time lag between practice implementation and publication. Moreover, such approaches offer limited insight into researchers' awareness, which is critical for informing training initiatives. Triangulation of these methods can provide more reliable estimates of open research awareness and use that can be tracked longitudinally to evaluate behaviour change.

## 7. Conclusion

We explored awareness and use of 11 common open research practices in a large international sample of multidisciplinary researchers. In general, awareness and use were highest for OA Publications and lowest for Registered Reports. Furthermore, there was an awareness–use gap across all practices and important variations between regions, disciplines, methodologies and career stages. These findings highlight the need to consider when open research implementation is applicable, possible and appropriate. Estimates of open research awareness can inform training, while estimates of use can inform policy development and longitudinal evaluations of behaviour change. Qualitative responses provide further insight into opportunities and barriers to adoption. Informed by the COM-B model of behaviour change, our findings further identify that initiatives which target social and physical opportunity (e.g. incentives from funders and institutions, dedicated funding and recognition) and psychological capability (more information and training) may increase adoption of open research practices.

**Ethics.** The study was approved by the ethics committee at the lead institutions (refs: 36606-LR-May/2022-39378-2; 36606-A-May/2023-44788-1), and all respondents provided informed consent.

**Data accessibility.** All materials, code, data and supplementary material are available on the Open Science Framework [82].

Supplementary material is available online [104].

**Declaration of AI use.** We have not used AI-assisted technologies in creating this article.

**Authors' contributions.** C.R.P.: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing—original draft, writing—review and editing; E.N.: conceptualization, investigation, methodology, resources, software, writing—review and editing; M.S.: investigation, validation, writing—review and editing; Y.B.: validation, writing—review and editing; R.M.: investigation, visualization, writing—review and editing; O.B.A.: investigation, resources, writing—review and editing; M.A.: investigation, software, writing—review and editing; A.A.: investigation, writing—review and editing; R.A.A.: investigation, writing—review and editing; J.B.: investigation, writing—review and editing; N.B.: investigation, writing—review and editing; L.M.P.B.: investigation, writing—review and editing; M.G.B.: investigation, writing—review and editing; I.E.B.: investigation, writing—review and editing; S.E.B.: investigation, writing—review and editing; A.B.: investigation, writing—review and editing; M.R.D.B.: investigation, writing—review and editing; I.B.: investigation, writing—review and editing; C.C.A.: investigation, writing—review and editing; H.C.: investigation, writing—review and editing; V.Č.: investigation, writing—review and editing; W.C.: investigation, writing—review and editing; S.C.: investigation, writing—review and editing; K.C.: investigation, writing—review and editing; A.C.: investigation, writing—review and editing; F.P.C.: investigation, writing—review and editing; D.C.: investigation, writing—review and editing; D.A.E.: investigation, writing—review and editing; T.M.E.: investigation, writing—review and editing; E.K.F.: investigation, writing—review and editing; G.F.: investigation, writing—review and editing; R.F.: investigation, writing—review and editing; P.G.: investigation, writing—review and editing; S.G.: investigation, writing—review and editing; H.H.: investigation, writing—review and

editing; V.C.H.: investigation, writing—review and editing; G.H.: investigation, writing—review and editing; M.I.: investigation, writing—review and editing; A.I.: investigation, writing—review and editing; A.J.: investigation, writing—review and editing; V.J.: investigation, writing—review and editing; Y.A.K.: investigation, writing—review and editing; T.K.: investigation, writing—review and editing; V.M.K.: investigation, writing—review and editing; H.E.K.: investigation, writing—review and editing; M.L.: investigation, writing—review and editing; M.L.: investigation, writing—review and editing; F.L.: investigation, writing—review and editing; M.T.L.: investigation, writing—review and editing; M.M.: investigation, writing—review and editing; H.M.: investigation, writing—review and editing; M.M.: investigation, writing—review and editing; D.M.: investigation, writing—review and editing; D.P.M.: investigation, writing—review and editing; S.N.: investigation, writing—review and editing; H.N.: investigation, writing—review and editing; G.N.: investigation, writing—review and editing; C.P.: investigation, writing—review and editing; S.P.: investigation, writing—review and editing; E.S.P.: investigation, writing—review and editing; R.M.R.: investigation, writing—review and editing; J.R.: investigation, writing—review and editing; B.R.: investigation, writing—review and editing; M.S.: investigation, writing—review and editing; F.D.S.: investigation, writing—review and editing; S.S.: investigation, writing—review and editing; M.S.: investigation, writing—review and editing; J.S.: conceptualization, writing—review and editing; S.L.K.S.: investigation, writing—review and editing; E.S.T.: investigation, writing—review and editing; L.U.: investigation, writing—review and editing; M.V.: investigation, writing—review and editing; V.V.: investigation, writing—review and editing; N.C.W.: investigation, writing—review and editing; Y.Y.: investigation, writing—review and editing; C.Y.: investigation, writing—review and editing; N.Y.: investigation, writing—review and editing; M.Z.: investigation, writing—review and editing; M.F.Ž.: investigation, writing—review and editing; M.M.: conceptualization, investigation, methodology, supervision, writing—review and editing; K.C.: conceptualization, investigation, methodology, software, writing—review and editing.

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