Topic Brief:
Guidance for Reporting on Studies of Open and Equitable Scholarship

Micah Altman, Center for Research Equitable and Open Scholarship, MIT Libraries, MIT

Abstract. The absence of standardized measurement and reporting hinders progress toward more reliable and equitable scientific practices. This topic brief summarized existing practice across stages of the research lifecycle to promote transparency and reliability, and to support the evaluation of participation and equity. The brief also discusses issues surrounding integrating these practices within the context of limited-term fellowship programs.

1. Introduction

The absence of established measurement and reporting guidelines limits our ability to collaborate on, learn from, and compare scientific interventions in open scholarship (Altman, Cohen, Polka 2023; Cole, et al. 2024). Complicating this, there is growing evidence that the design and implementation of open science practices may have substantial and heterogeneous effects on who participates in science, and on how the benefits of scientific outputs are distributed (Altman, Bourg, et al. 2018; Maron et al. 2019; Altman, Cohen, Polka 2023).

This topic brief examines emerging standards and recommended practices for conducting research in open and equitable science that is collaborative, replicable, and comparable. It highlights recommended practices at each stage of the research lifecycle: including documentation of research design; standardization of measurements; transparent and collaborative conduct of research; and accessible dissemination of research results and evidence. It then provides recommendations for integrating these standards and practices into a program of time-limited extra-mural research projects on equitable and open scholarship.

2. Standards and Practices over the Research Lifecycle

Overview - The Emergence of Open Science as Best Practice

Open access is rapidly becoming the best practice for scientific publications and a growing number of research funders are adopting open-access mandates (Mering, 2020; Lioa, 2022; Robinson-Garcia 2020). In parallel, there has been an increase in the recognition of open science practices. There is now a compelling body of evidence documenting the endemic lack of replicability in scientific research, along with gaps in practices related to transparency, reporting, replicability, and comparability - along with an emerging set of open science practices responding to these gaps (NASEM-BCBSS, 2019; Hardwicke et al., 2020).

A broad consensus has now emerged that scientific practices should be designed to promote transparency and trustworthiness (Altman & Cohen, 2022). Further, adopting open science practices, including data sharing, preregistration, and preprinting, is becoming increasingly widespread (Ferguson et al., 2023; Ni & Waltman, 2023). While the development of open science practices is ongoing, there is now recognition of a set of baseline best practices for open science and research reproducibility including standardized reporting, preregistration of studies and analyses, preprinting of research, data sharing, and sharing of replication code (Nosek et al., 2015; BASEM-BRDI, 2018; NASEM-BCBSS, 2019; Hardwicke et al., 2020; Grant et. al 2022, Table 1).

There is a concurrent recognition that participation in and the effect of various science practices can be heterogeneous. Further heterogeneity of participation or treatment effect may depend strongly on an individual's demographic characteristics. In turn, this substantially affects the function and outcomes of operational science policies (see Altman, Cohen & Polka 2023) such as peer review, scientific mentoring, and open-access publication. There is growing concern that in particular gender, race, English-language fluency, disability status, and the resources available in a scholar's institution (strongly associated with institutional nationality) influence outcomes because of direct effects on individual treatment, or their interaction with structural differentiation in prior treatment (see e.g. Jeannis et al. 2017; Lee et al. 2013, Ceci et al 2023; Kleibel and Hellauer 2023).

Adopting and maintaining effective open science practices requires supporting infrastructure, policies, and education (NASEM-BRDI, 2018). Research institutions that aim to support open science practices should provide education, and establish policies that meet the requirements for open and trustworthy research across lifecycle stages (NASEM-BRDI 2018; Borgman 2019) and multiple researcher roles (Brand, et. al 2015). Additionally, research institutions must support access to the infrastructure that provides the core affordances needed for scientific research (see Nasem-BRDI 2018; Pacheco 2022, Barathi, et al 2008; Cioffi et al. 2023).

Preparing for study:
Ideation, Search, and Design

At the outset of research, open and collaborative processes and infrastructure should be adopted that support ideation, conceptualization, and annotation activities. In planning research, transparent and reproducible tools and approaches should be employed for bibliographic searches, management, and literature review (Page et al., 2021).

Research design should identify an approach that contributes to the cumulative evidence base by describing the scholarly ecosystem and incorporating externally comparable measures of primary outcomes, quality, cost, burden, and inclusion (Altman, Cohen, Polka, 2024). The design should clearly define the population frame, the population of interest, the hypothetical interventions under consideration, and the strategy for identifying causal effects (Hernan and Robins, 2020; Gerber and Green, 2012).

These target populations of interest should be diverse in terms of gender, disability, nationality, and race unless there is a strong scientific rationale for focusing on a specific subgroup. Additionally, the study should aim to reflect the diversity of the population of interest within the population frame and sampling design (Laplante et al., 2022).

Data collection and consent processes should be designed to facilitate open data sharing, replicability, comparability, and reuse (NASEM-BCBSS, 2019; Hardwick et al., 2018; Altman, Cohen, Polka, 2024). Data collection designs should be stratified (see Groves et al 2009) to provide adequate power to detect meaningful differences in treatment effects by individual demographic characteristics. When conducting research with Indigenous populations or vulnerable subjects, consent and data protection measures should prioritize respecting individual or tribal data sovereignty while enabling validation and replication, recognizing that additional consent may be necessary for data reuse in other research (Carroll et al., 2020; Cole et al., 2020).

Data collection mode notwithstanding, to develop a reliable understanding of inclusion and participation in science over time, research design should include standardized and comparable measures of demographics.

- Subject demographics for open science research should include measures of gender (NASEM-CMSGISO, 2022) and of the development class of the participant's country of employment (UNDP, 2022) - as these characteristics have the potential to substantially affect the selection to scholarly interventions, affect the exposure, the intervention received, and influence the potential outcomes from science process interventions. Where secondary data or administrative data collection is used, these characteristics can often be reliably imputed (respectively) from personal names, and institutional names or addresses (see Sebo 2021; Lammey 2020).

- Where a particular open science practice or policy is being studied, research designs should include a standardized taxonomy of open science activities, including the TOP categorization (Mayo-Wilson, et al 2021), to describe the intervention. When it is possible, collect comparable measures of attitudes and behaviors relevant to that category of open science behavior, using an established instrument, including appropriate OSS modules (COS, 2023).
- Where it is feasible to collect demographic data directly from subjects, or where the question being studied involves long-term process or close interaction across participants, measuring ethnicity, race, and gender orientation should be included if possible, and simple, established, and comparable measures and instruments should be employed (see, respectively; NCSES 2021; NASEM-CMSGISO 2022).

Conducting research:
Data Collection and Curation, Analysis, Interpretation, Writing

To support both ongoing collaboration and planned open dissemination use a consistent infrastructure that supports support asynchronous collaboration, provides reliable revision tracking and control, and can permit use by anyone. Avoid using infrastructure that is, by design, restricted to use by members of a specific organization, country, etc. Actively manage, document, and communicate authorship, contributorship, and revision management as the work is in progress – whether or not the current version is being made openly available.

At the project's inception, plan to publish research in Open Access journals and anticipate the need to fulfill open science publication requirements. Clearly define and communicate a contributor's roles and responsibilities and review these as needed at key milestones, such as when individuals join or exit the research project or host institution. The standardized CRediT taxonomy (Allen et al. 2014) should be used to document contributor roles and a foundation for providing transparency regarding attribution when publishing (McNutt et. al 2018).

To enhance transparency and rigor, preregister a research and analysis plan before collecting any data (Schwab et al., 2022; NASEM-BCBSS, 2019). To promote data integrity, security, and confidentiality, develop a comprehensive data management plan and data curation procedures that ensure data provenance, fixity, authenticity, and version control from the beginning of data collection through the publication of results (ICPSR, 2024; Gray et al., 2002).

Adopt a systematic and reproducible approach to data processing and analysis, enabling the consistent recreation of processed data from original data or clear traceability of qualitative/human coding (Wilson et al., 2017; NASEM-BCBSS, 2019; Peng and Hicks, 2021; Sandve et al., 2013). Develop publications using executable paper (or notebook) tools if possible, and at minimum automate the generation of tables, results, and figures in publications and reports to support revisions, reliability, and reproducibility (Wilson et al., 2017; Gentleman and Temple-Lang, 2007; Stodden et al., 2014).

Dissemination and evaluation:
Publishing, Archiving, Evaluation

To capitalize on the benefits of early sharing, clearly establish attribution, and facilitate derivative work preprinting should be a mandatory project milestone (Bourne et al., 2017). Preprints and subsequent publications should explicitly reference the pre-registered design and clearly outline any deviations, additional hypotheses, or analyses (Nosek et al., 2015).

Published results should enhance comparability and cumulative knowledge by adhering to standardized reporting checklists and transparently disclosing uncertainties, adverse events, and potential externalities (Hardwicke et al., 2020; Altman, Cohen, Polka, 2024).

It is essential to accompany preprint publication with data and replication materials in FAIR-compliant archives maintained by institutions committed to long-term preservation (Wilkinson et al., 2016). Disseminate preprints and final publications, data, and code under open licenses that permit reuse, extension, redistribution, and the creation of derivative works (Schwab et al., 2022; NASEM-BCBSS, 2019).

After publications, track both leading altmetrics indicators of use and engagement, as well as lagging indicators of citation impact to assess research influence (Bornmann, 2014).

3. Discussion -- Integrating Open Science into Fellowship Programs

Creating more equitable open science requires establishing a mechanism to engage a diverse set of scholars in the pursuit of answers to current and future questions on how to build an open and equitable world of research. How should open-science practices be integrated into such fellowships?

The fellowship program structure, while offering unique opportunities to broaden participation in research, also requires engaging individuals from outside of the hosting institution, to work on a research question that is new to them, for a limited time. As a consequence, fellowships are often constrained by several factors:

- *Time and resource limitations*: Research projects typically have defined timelines and budgets, restricting the scope and depth of investigations.
- *Focus on individual projects*: A fellowship program's emphasis on individual research projects can sometimes limit the overall impact and broader contributions to the field.
- *Evaluation and dissemination:* Publishing research, and evaluating its impact often requires substantial time beyond the main research phase. Sustaining evaluation and dissemination activities beyond the fellowship period requires additional resources and commitment. And the departure of fellows can disrupt project momentum and hinder long-term evaluation and dissemination efforts.
- *Complex collaborative networks*: A successful fellowship requires collaborations with a diverse set of internal and external researchers - which present logistical, infrastructural, and communication challenges.

By curating, documenting, integrating, and supporting open science best practices, the host institution can promote a range of individual, program, and community objectives, particularly:

- Enhancing the reputation of individual researchers by increasing the visibility and trustworthiness of their research.
- Foster a collaborative environment by supporting the exchange of knowledge and ideas among past, current, and future fellows, as well as internal and external collaborators.
- Increase visibility, accessibility, and impact of research findings through effective dissemination strategies.
- Promote critical evaluation of research outputs and processes.
- Contribute to the advancement of open science by generating evidence on the efficacy of open science interventions.
- Build a stronger, more collaborative research ecosystem through the sharing of knowledge and resources.

Recommendations for integrating practices and standards

A successful research program requires practices, standards, and infrastructure that promote visibility, discussion, and dissemination. These must function not only for a single project but across a series of independently created research projects that involve a dynamic community of past, current, and future fellows and intra- and extra-mural-collaborators. Further, it is expected that fellows will come from diverse communities of practice, have uneven familiarity with open and reproducible science practice, and have limited time to develop new practices. As a result, **host institutions should establish program-wide standards and practices at launch to address the areas described in the previous section. Further, host institutions should take ongoing responsibility for documenting these standards and practices; communicating them both internally and publicly; updating them; and and supporting their use by the Fellows and collaborators.**

Successful use of open science practice depends critically on access to knowledge infrastructure that supports collaborative project research planning, authoring, and data curation. As described in Section 2, a satisfactory infrastructure should provide: affordances for persistence, revision history, persistent identification, attribution, commentary (annotation), and attribution; and will support research lifecycle activities including data storage, computing, developing code, and maintaining lab notebook or other research records, and writing scholarly articles. Further, this infrastructure will need to be durably available to current fellows, past fellows, and extra-mural collaborators. As a result, **host institutions should identify, ensure access to, and provide durable support for a coherent infrastructure that enables fellows and collaborators to complete research across the full research lifecycle.**

The research projects conducted by fellows are generally tightly bounded in scope and time, and much of the attention of the participants will be limited to the period of their (virtual) residence at the host institution. In contrast, the host institution has long-term interest in project sharing, reuse, evaluation, and impact that extends beyond the residence time of fellowship.

As a result, **practices and infrastructure should include continuous integration practices that support asynchronous independent collaboration and are "open-ready" - where broader (or public) access can be enabled at any time, punctuated by sharing milestones within the primary project period.** Several open science practices described in section 2, including pre-registration, reproducible data curation, executable papers, early preprint, use of collaborative version control systems, and FAIR data and software, can naturally strengthen continuous integration and collaboration.

Appendix - Exemplar tools:

Pre-publication		
Desk research	Bibliography: sharing references, article collections	Zotero
	Annotation: sharing annotation on documents	Hypothes.is
	Systematic reviews, and bibliographic information retrieval and analysis	PRISMA, Task View: Reproducible Research
Writing	Authoring: small-scale collaborative authoring of texts	Google docs
	Authoring: small through large-scale collaborative authoring, coding, analysis, and programming projects	Git + Github
	Authoring: executable articles, programming, literate programming, executable notebooks	QUARTO, Posit;
Data Curation	Data storage and versioning: medium-scale	Google workspace, OSF.io
	Data-storage, and versioning: large-scale	AWS
Post-publication		
Writings	Pre-print sharing	OSF.io, arXiv
Data	Data archiving	Dataverse, OSF.io, Zenodo
Code	Code publication / sharing	Github, Dataverse, OSF.io, CRAN

Table A1: Selected Tools for collaborative research & open science

Author Contributions

Authors are listed in alphabetical order. We describe contributions to the paper using a standard taxonomy (see Allen et al. 2014). All authors take equal responsibility for the article in its current form. MA was primarily responsible for conceptualization, analysis, and writing. All authors contributed to the review through commentary on the manuscript.

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