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https://pathos-project.eu/

https://doi.org/10.7557/5.7808

PathOS

Open Science Impact Pathways

The Impact of Open Science

what do we really know?

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19th Munin Conference on Scholarly Publishing

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Open Science Impact Pathways

Programme: Horizon Europe (WIDERA)

Consortium: 10 international partners. Experts in *Metaresearch, Scientometrics, Econometrics, Science & Society, Science Policy, Research Infrastructures*

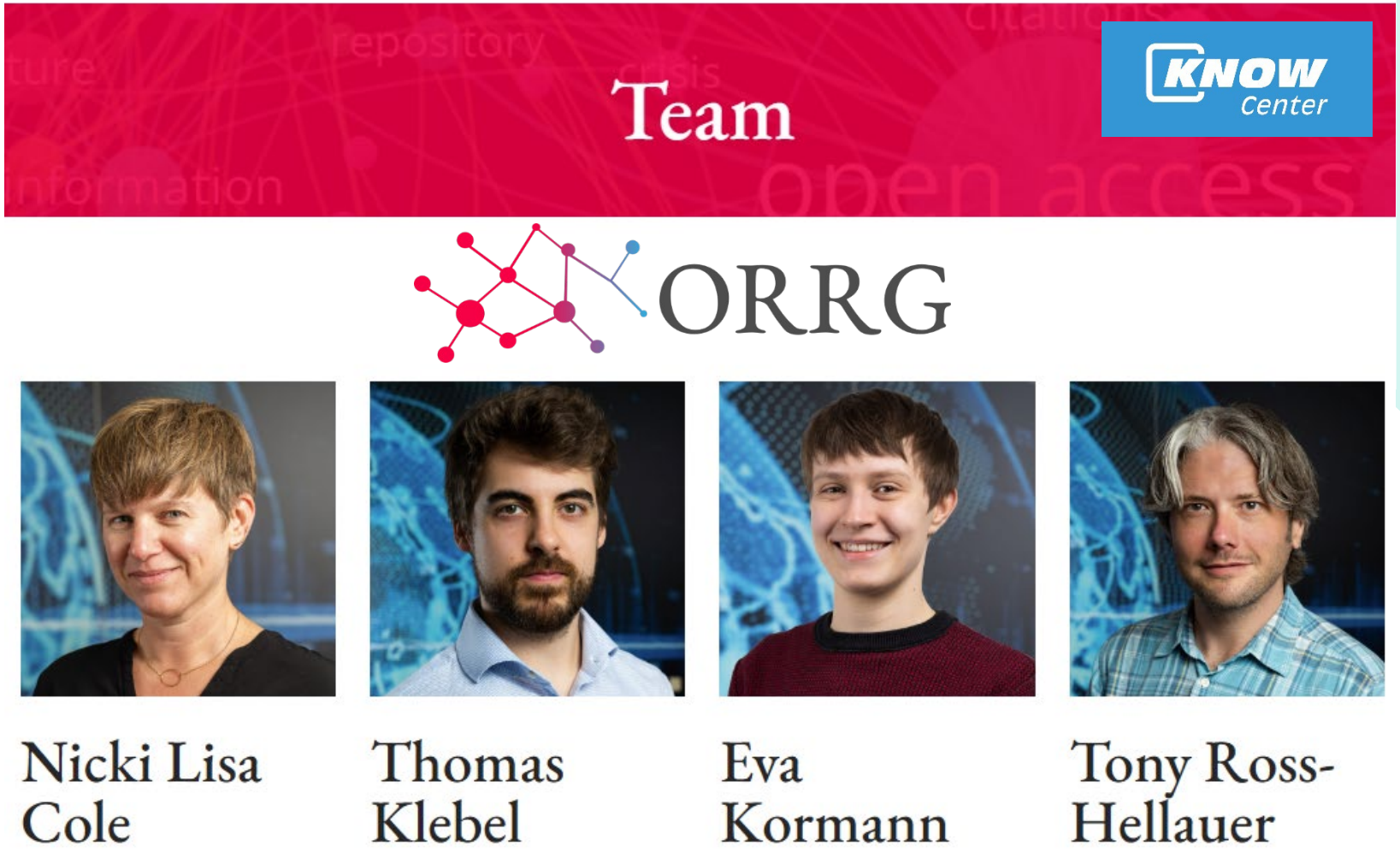
Duration: Sep 2022 – Aug 2025 (36M)

Budget: €2M

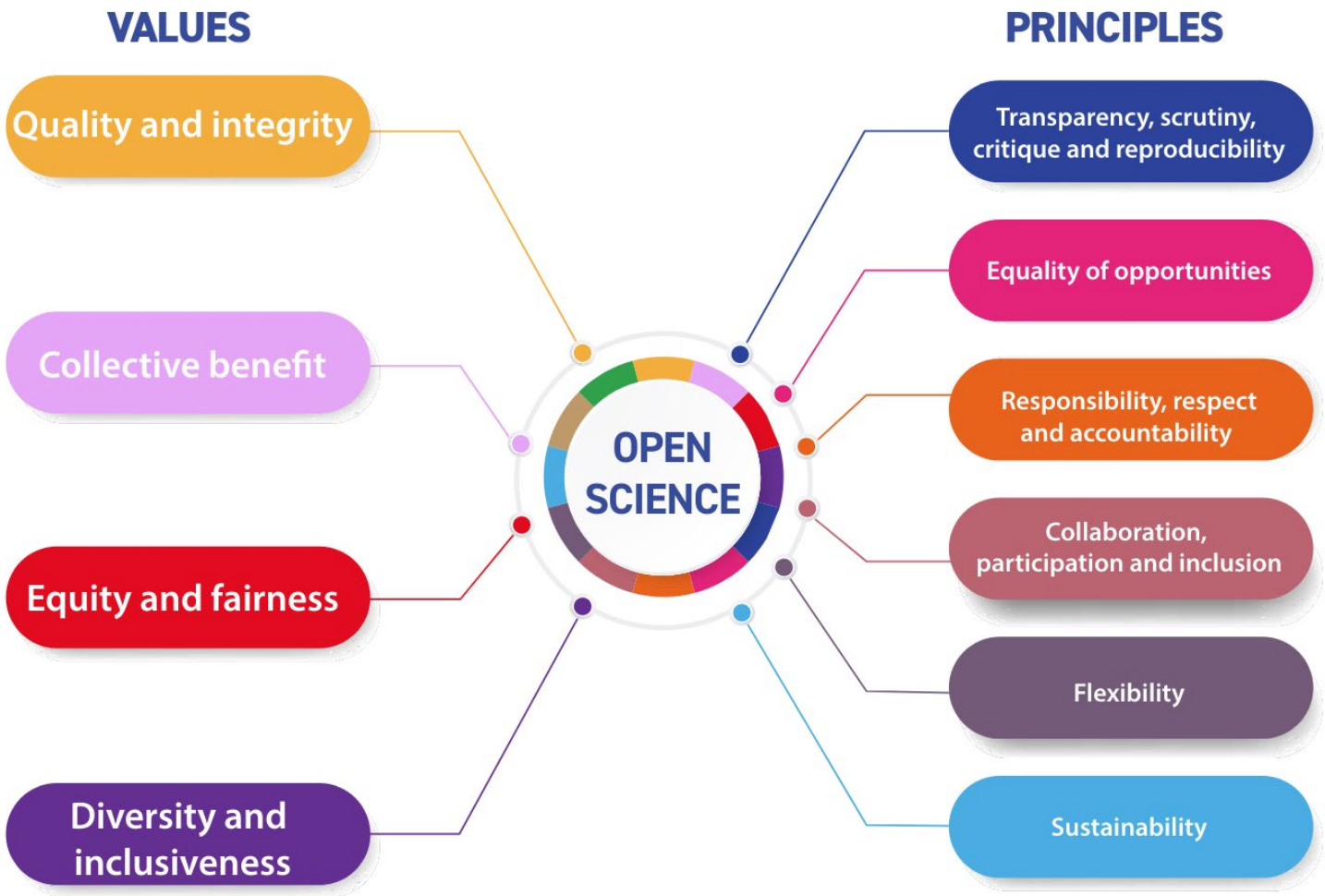
Website: https://pathos-project.eu/

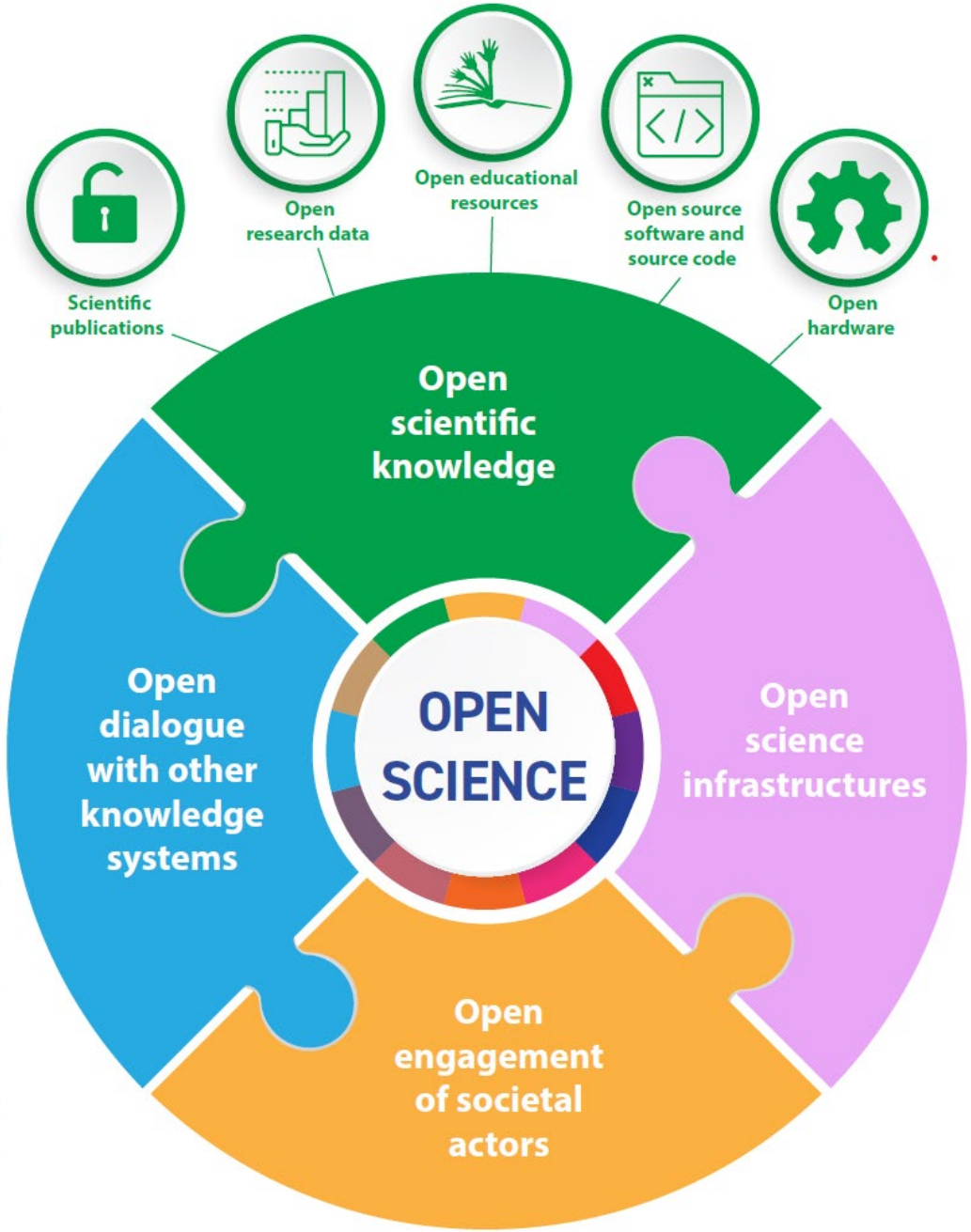
The Open & Reproducible Research Group

- Based at Know Center Research GmbH in Graz, Austria
- Metaresearchers studying the effects and impacts of services, policies, and practices to make research more open, responsible and reproducible



Open Science is a plurality





Images from UNESCO Recommendation, CC-BY-SA

OS transition, investments, expectations & impact

- Open Science is not a unified ideology but a diverse bunch of principles and practices
- There are various routes to implementation of Open Science; the “how” is crucially important
- Impact comes in many shapes and forms, very often intangible
- Are we investing in the right instruments to truly realize the promise?
- Are we achieving expected outcomes?
  - Are there unintended consequences?
- What key pathways and enablers are driving impact?
- How can we measure and monitor impacts and accurately attribute them to Open Science?

PathOS objectives

Identify and quantify the **Key Impact Pathways of Open Science** across **academia**, **society**, **and the economy** to enhance understanding and drive informed policy-making.

Beyond state of the art

- Map the **Causal Pathways** for Open Science
- Design and estimate **OS Impact Indicators** for selected case studies
- Use **data-driven, AI-assisted** methodologies
- Formulate a **Cost-Benefit Analysis** framework for Open Science

How are we monitoring Open Science?

Example: **French Open Science Monitor**

https://frenchopensciencemonitor.esr.gouv.fr/

Impact is relatively underexplored so far

The primary focus has been measuring ***uptake***, not ***impact***

- **Uptake:** Monitoring and measuring whether researchers, institutions, nations implementing OS practices
- **Impact:** Monitoring and measuring the long-term, elementary and wide-spread changes attributable to Open Science

Understanding impact is essential for knowing whether the intended longer-term ambitions of transition to Open Science (greater quality, equity, reproducibility, inclusion, innovation, …) are actually being realised?

So what evidence is there about the impact(s) of Open Science?

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Methods

PRISMA
TRANSPARENT REPORTING OF SYSTEMATIC REVIEWS AND META-ANALYSES

Studies followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) methodology

- Step 1: Identify relevant studies
  - Academic literature in Scopus, Web of Science, OpenAlex, grey literature
- Step 2: Selection of eligible studies by screening titles, abstracts, then full-texts
  - Academic, Societal, Economics impacts of Open Science and its constituent practices (Open Access, Open/FAIR Data, Open Methods, Open Code, Citizen Science, Open Evaluation)
- Step 3: Data extraction from included studies
  - Key information: methods, findings, type of impact, aspect of OS
- Step 4: Synthesis of data and reporting
  - Pre-registered protocol: https://osf.io/m4rnc
  - Final results reported in 3 separate papers (Academic, Societal, Economic impacts)

High-level concept	Element of OS	Impact	Academic Impact	Societal Impact	Economic Impact
Lower-level concepts	Open Science Open Access Open/FAIR Data Open Methods Open Code Citizen Science Open Evaluation	Effect Outcome	Efficiency Productivity Quality Education Reproducibility Reuse Citations Collaboration Equity, Diversity and Inclusion	Societal impact Trust Education/understanding Engagement Government policy Sustainable Development Goals Environment/climate Health COVID Participation	Economic impact Financial/monetary impact Cost/benefit analysis Input-output modelling Return on investment Productivity Innovation Patenting New products/services
Search terms	"open scien*" "science 2.0" "open data" "FAIR data" "open access" "open code" "citizen science" "open peer review" OR "open metric*"	impact* effect* outcome*	quality citation* integrity equi* collaborat* trust efficien* re-us* OR reus* productiv*	engag* educat* trust polic* sdg OR "sustainable development goal*" gender diversit* health environment* OR climat* covid* OR coronavirus* participat*	econom* financ* cost* mone* cba bca "input-output" "return on investment" "patent*" "innovation*" "efficiency gain*" "saving" "product*"

Academic impact: 489 included studies

The academic impact of Open Science: a scoping review

Keywords: academic impact, open science, open access, FAIR data, citizen science, scoping review

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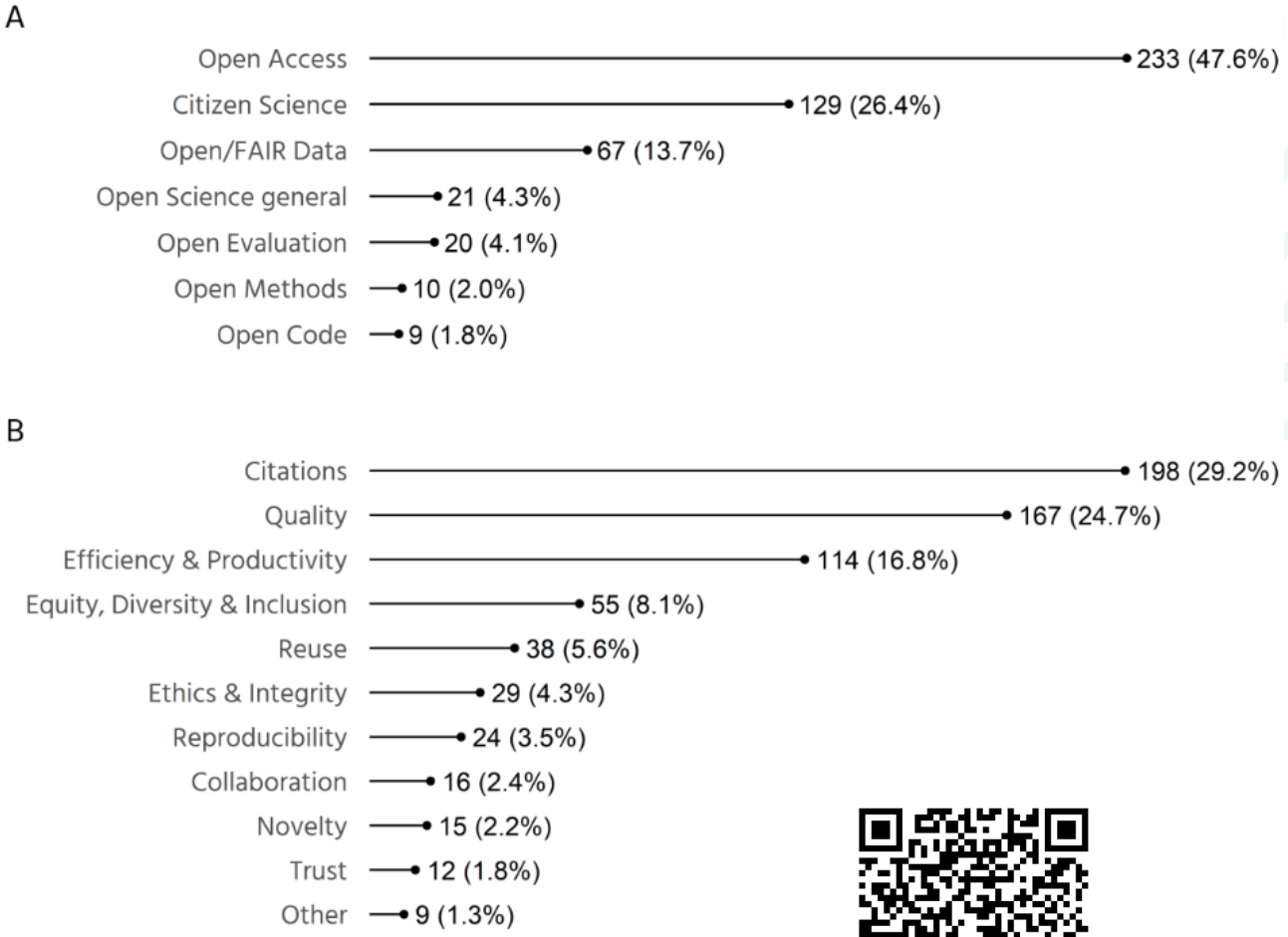
Abstract

Open Science seeks to make research processes and outputs more accessible, transparent, and inclusive, ensuring that scientific findings can be freely shared, scrutinised, and built-upon by researchers and others. To date, there has been no systematic synthesis of the extent to which Open Science reaches these aims. We use the PRISMA scoping review methodology to partially address this gap, scoping evidence on the academic (but not societal or economic) impacts of OS. We identify 489 studies related to all aspects of OS, including Open Access (OA), Open/FAIR Data (OFD), Open Code/Software, Open Evaluation, and Citizen Science (CS). Analysing and synthesising findings, we show that the majority of studies investigated effects of OA, CS, and OFD. Key areas of impact studied are citations, quality, efficiency, equity, reuse, ethics, and reproducibility, with most studies reporting positive or at least mixed impacts. However, we also



Preprint available at https://doi.org/10.31235/osf.io/ptjub

Academic impact: Main findings

- **Citations**
  - Small to moderate increase from OA, Open/FAIR Data, and Open Evaluation
  - Unclear effects from Open Code, no effect from OS badges
- **Quality**
  - Neutral to moderate positive effects from Open Peer Review
  - Conflicting evidence from OA, Citizen Science neutral effect on quality given sufficient training
- **Efficiency & productivity**
  - Positive effects from Citizen Science, OA, and Open Science in general
  - Unclear effect of Open Evaluation
  - Wasted time from predatory publisher emails (OA)
- **Equity, diversity and inclusion**
  - OA leads to more diverse citations and international collaboration
  - Marginalization of those with fewer resources (OA-APC, Open/FAIR Data) or lower status (Open Evaluation)
  - Citizen Science activities focused in the Global North
- **Reuse**
  - Positive effect of Open/FAIR data
- **Reproducibility**
  - Positive effects of preregistrations and registered reports
  - No effects of Open/FAIR Data or Open Methods
- **Novelty**
  - Potentially positive effect of OS practices on rate of true discoveries
- **Ethics & Integrity**
  - Unclear impact of Open Evaluation on integrity of reviews
  - Open/FAIR data has risk of re-identifying participants
- **Trust**
  - Positive effect of OS badges on trust in results by scientists.

Societal impact: 196 included studies

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Review

Check for updates

Cite this article: Cole NL, Kormann E, Klebel T, Apartis S, Ross-Hellauer T. 2024 The societal impact of Open Science: a scoping review. *R. Soc. Open Sci.* **11**: 240286.
https://doi.org/10.1098/rsos.240286

Received: 19 February 2024
Accepted: 20 May 2024

The societal impact of Open Science: a scoping review

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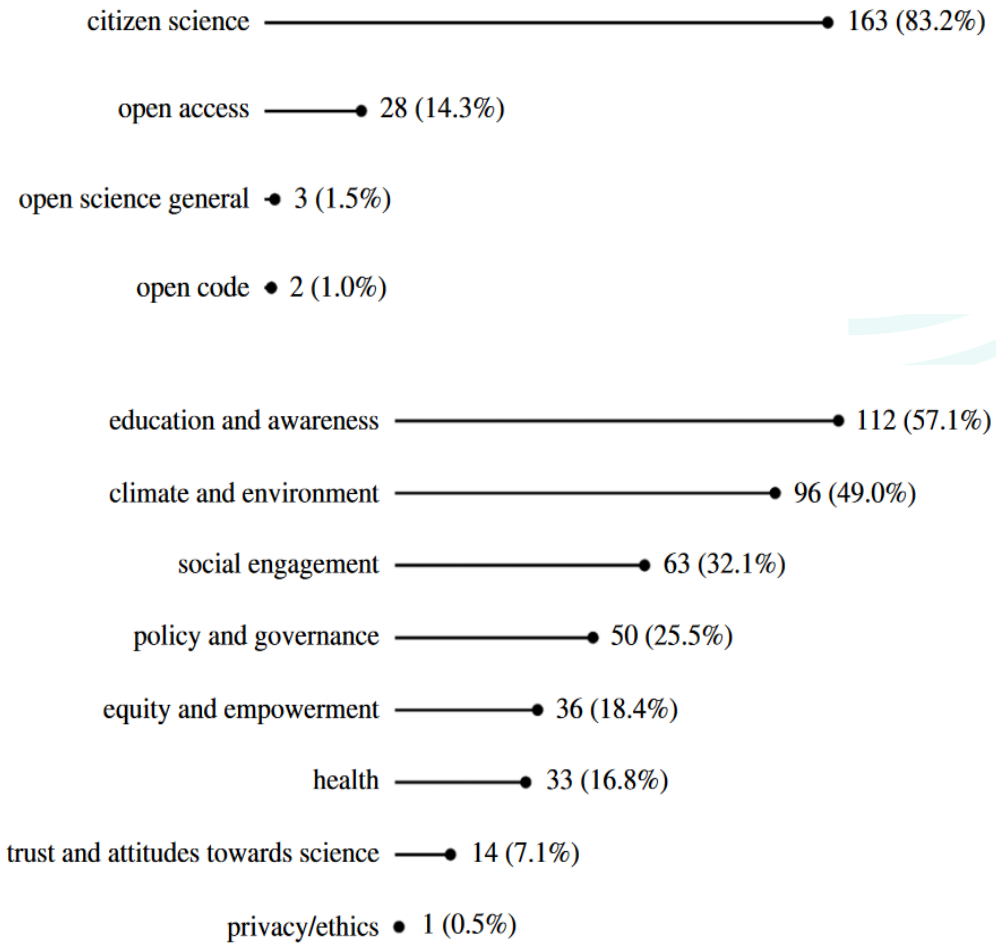
Open Science (OS) aims, in part, to drive greater societal impact of academic research. Government, funder and institutional policies state that it should further democratize research and increase learning and awareness, evidence-based policy-making, the relevance of research to society's problems, and public trust in research. Yet, measuring the societal impact of OS has proven challenging and synthesized evidence of it is lacking. This study fills this gap by systematically scoping the existing evidence of societal impact driven by OS and its various aspects, including Citizen Science (CS), Open Access (OA), Open/FAIR Data (OFD), Open Code/Software and



[Cole et al. 2024]

Societal impact: findings and challenges

- Mechanisms that drive impact: public participation, collaborative creation of data, uptake of data and stakeholder engagement, signaling OS
  - CS data creation serves unmet data needs
  - Stakeholder engagement strengthens social ties and drives equity and empowerment
  - OS badges and OA leads to greater engagement and trust
- Challenges/evidence gaps
  - A lack of evidence outside of CS and OA
  - No evidence of impact from Open/FAIR data identified
  - Questionable evidence of societal impact from Open Access (altmetrics)
  - Difficult to measure and study societal impacts in the medium and long-term

Societal impact: Significance of participatory mechanisms

- Public participation in research drives a wide variety of societal impacts
  - More science policy and funding for societal inclusion in research, and more institutional acknowledgement of its value
- Integration of CS in classrooms supports learning outcomes and skill development
  - Evidence shows success in K-university settings; can be deployed within sociology classrooms
- Community-led research can effectively respond to problems
  - Researchers can take a mission-oriented approach to helping communities respond to social, environmental and economic problems

Economic impact (work in progress)

Content of the literature

- Scarce company data
- Many theoretical papers on expected gains, but few with real evidence
- Most papers on Open Science, Open Access and Open Data, few on Citizen Science, Open Source or Open Code
- Most evidence comes from the medical and biotech sector

Challenges/evidence gaps

- Great difficulties in identifying either business (turnover/profits) or macroeconomic impacts
- A lot more case studies and broader assessments are needed to allow for meta-analyses

Challenges

- **Causality**/correlation: difficulty of directly measuring relationships between interventions, outcomes, and impacts

- Lack of **standards** for defining and measuring OS impact

Challenges

- Many **case studies**, often from those linked to initiatives
  - Case studies often difficult to generalize due to local contexts.
  - Is there a risk of publication bias from initiatives effectively evaluating themselves?
- **Streetlight effect** – measuring what's easy to measure
  - E.g., OA impact – a huge number of studies on OA citation advantage
  - Are we working enough to effectively measure progress on other Open Science aims (increasing quality, reproducibility, inclusion, innovation, etc.)

Implications

- **Lack of robust evidence**, except in key areas – knowledge gaps should be addressed
- Need to better **orchestrate, fund and sustain impact monitoring/evaluation efforts**, especially those which employ **strong causal methods**
- Vice versa, some areas with strong evidence of impact (e.g., Citizen Science) have a **lack of policy support and funding**
- Monitoring of Open Science should increasingly **focus on *impact* rather than *uptake***
- Qualitative and mixed methods approaches are needed to study impact pathways

PathOS OS Indicator Handbook

https://handbook.pathos-project.eu/

- Covers various aspects of quantifying impacts of Open Science
- Covers indicators for Open Science uptake, academic, societal, and economic impact, and reproducibility
- If an indicator can be readily operationalised, we provide ready-to-go recipes to support its implementation
- Also include more speculative indicators, not yet easily operationalised
- Includes opening chapter with introduction to causality in science studies

Publications and next steps

- **Preprint of full results for academic impact:** Klebel, T., Traag, V., Grypari, I., Stoy, L., & Ross-Hellauer, T. (2024). *The academic impact of Open Science: A scoping review*. OSF. https://doi.org/10.31235/osf.io/ptjub
- **Publication for societal impact:** Cole, N. L., Kormann, E., Klebel, T., Apartis, S., & Ross-Hellauer, T. (2024). The societal impact of Open Science: A scoping review. *Royal Society Open Science*, *11*(6), 240286. https://doi.org/10.1098/rsos.240286
- **Write-up of full results for economic impact underway**
- **Initial report on database search results:** Klebel, T., Cole, N. L., Tsipouri, L., Kormann, E., Karasz, I., Liarti, S., Stoy, L., Traag, V., Vignetti, S., & Ross-Hellauer, T. (2023). PathOS - D1.2 Scoping Review of Open Science Impact. Zenodo. https://doi.org/10.5281/zenodo.7883699
- **Zotero library available:** https://pathos-project.eu/os-impact-evidence-library

Thank you

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Funded by the European Union

https://doi.org/10.7557/5.7808