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Does open access strengthen the link between online attention and citations?

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Does open access strengthen the link between online attention and citations?

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Abstract

Altmetric Attention Scores are often proposed as early signals of later citations. We test whether open access (OA) changes this relationship by comparing OA and non-OA articles within the same hybrid journals. Study 1 uses 60,565 articles published mainly in 2018 in 1,275 Springer hybrid journals, with attention recorded in 2021 and citations in 2022–2026. Attention predicted later citations more strongly for hybrid OA articles, made open at publication, than for other articles (Spearman $\boldsymbol{\rho = 0.38}$ vs **0.19**). After exact matching, a gap of 0.06 (95% CI 0.03–0.10) remained; it shrank further once early citations were controlled. Downloads accounted for most of the attention–citation link. A natural experiment, in which national agreements made hybrid OA the default in several European countries, points to causal effects of OA on attention, downloads and citations: in the same journals, articles from these countries received 29% more citations, while their non-hybrid articles were not cited more. The hybrid OA citation advantage declined as journal impact factor rose. In Study 2, covering 7,073 *Nature* articles, OA brought no citation advantage over closed articles. In Study 3, Altmetric data on Colombian research show that the gap lies in public attention (news, blogs, X), not in Mendeley readership. Hybrid OA was concentrated among authors in high-income countries and top-ranked universities. Altmetric scores are thus a somewhat better proxy for citations when articles are free to read, but a poor substitute for citations in assessment.

Keywords: Altmetrics, Altmetric Attention Score, Citation analysis, Open access, Hybrid journals, Scholarly communication

1 Introduction

Citation counts are the traditional measure of an article's academic impact. They have known limits. Citations accumulate slowly. They also miss reading, downloading, recommending and sharing (W. Huang, Wang, & Wu, 2018). Alternative metrics, or altmetrics, aim to capture this wider and faster attention (Piwowar, 2013; Priem, Groth, & Taraborelli, 2012). The Altmetric Attention Score combines weighted mentions in news, blogs, social media, Wikipedia, policy documents and other sources into one number.

Whether attention predicts citations is debated. Correlations are usually positive but weak to moderate. They vary across fields and journals (Costas, Zahedi, & Wouters, 2015; W. Huang et al., 2018; Thelwall & Nevill, 2018). This variation suggests that other factors shape the relationship.

Open access is a natural candidate. OA makes the full text available to every reader, including those who share and discuss research online. OA is also linked to higher citation counts in many, though not all, studies (Langham-Putrow, Bakker, & Riegelman, 2021). Whether OA changes the strength of the attention–citation link itself has rarely been tested. Two recent studies suggest that it does. In Israeli publications, academic impact and societal engagement were more closely linked for OA than for closed articles (Hadad, Raban, & Aharony, 2025). In Korean funded articles, OA strengthened the path from social mentions through usage to citations in medicine, but not in the humanities and social sciences (Cho & Park, 2023). Both studies used one country's output, measured attention and citations at the same time, and compared articles across journals.

The publisher report on which our main dataset is based showed that hybrid OA articles receive more attention and more citations (Springer Nature, 2021a); it did not ask how the two are related. Comparing OA journals with subscription journals mixes OA with differences in quality, field and editorial practice. Following Harnad and Brody (2004), we compare OA and non-OA articles within the same hybrid journal. We do this in three studies. Study 1 covers 1,275 hybrid journals across 20 disciplines and measures attention before the citations it predicts. Within it, national OA agreements that made hybrid OA the default in five European countries provide a natural experiment, so OA does not depend only on author choice. Study 2 follows *Nature*, a multidisciplinary, highly cited journal, over 2015–2022. OA there arose only after publication until 2021, when a paid hybrid OA option was added. Study 3 uses per-source attention data to see which kinds of attention carry the OA difference.

We ask five questions:

1. Is the Altmetric Attention Score correlated with citation counts?
2. Does OA status moderate this correlation?
3. Does OA status affect citation counts and Altmetric scores?
4. Does the moderation differ across journals and fields?
5. Which attention sources carry the difference?

2 Background

2.1 Open access and online scholarly communication

The Budapest Open Access Initiative defines OA as free online access to peer-reviewed literature, without financial, legal or technical barriers (Budapest Open Access Initiative, 2002). OA takes several forms. Gold OA is published OA, often with an article processing charge (APC). Hybrid OA is an OA article in a subscription journal. Bronze OA is free to read on the publisher site without an open licence. Green OA is a self-archived copy in a repository (Piwowar et al., 2018).

Digital tools and social networks let researchers reach wider and non-academic audiences (Schnitzler, Davies, Ross, & Harris, 2016; Weller, 2011). Document features also shape this sharing. Haustein, Costas, and Larivière (2015) showed that title length, document type and collaboration patterns affect social media visibility and citations differently.

2.2 Altmetrics and the Altmetric Attention Score

The term altmetrics came from the #altmetrics hashtag (Piwowar, 2013). Altmetrics assess research outputs by their activity on online platforms: social media, news, blogs, reference managers and others (Priem et al., 2012). Its premise is that such activity reflects real use of research (Torres-Salinas, Cabezas-Clavijo, & Jiménez-Contreras, 2013). Using social media for academic purposes led to new ways of measuring the reach of publications (Wouters & Costas, 2012). Altmetrics complement traditional citation-based measures (Galligan & Dyas-Correia, 2013).

The Altmetric Attention Score weights each mention by source and sums them (Altmetric, 2020; Chang, Desai, & Gosain, 2019). News carries the highest weight. Mendeley readers are tracked but not scored. The score is not stable over time. Deleted X (Twitter) posts and source changes altered the score of 23.7% of papers within a year (Arroyo-Machado & Torres-Salinas, 2024). X remains the main source, while Bluesky is growing (Arroyo-Machado, Robinson-Garcia, & Torres-Salinas, 2025).

2.3 Do altmetrics correlate with citations?

Eysenbach (2011) found that highly tweeted articles in their first days were much more likely to be highly cited. Costas et al. (2015) found field-dependent correlations, stronger for highly cited papers. Thelwall and Nevill (2018) showed that Altmetric scores in the publication year correlate positively with citations about three years later.

W. Huang et al. (2018) analysed six PLOS journals. They found significant correlations of varying strength in four of them, none in *PLOS Medicine*, and only partial ones in *PLOS Biology*. Small samples may explain the null results. In medicine, many studies report positive correlations (Barakat et al., 2019; Chang et al., 2019; Fassoulaki, Vassi, Kardasis, & Chantziara, 2018; Garcovich, Wu, Sucar, & Martin, 2020; Mullins, Boyd, & Corey, 2020). Others report none (Dixon & Baker, 2020; Warren, Patel, & Boyd, 2020). In Warren et al. (2020), median scores were only 0–1, which limits what a correlation can show. De Filippo and Sanz-Casado (2018) found no significant correlation in economics, sociology and communication.

2.4 Open access, citations and attention

Many studies report an OA citation advantage (Antelman, 2004; Eysenbach, 2006; Gargouri et al., 2010). Eysenbach (2006) found that OA articles in *PNAS* were twice as likely to be cited, and that OA at publication beat self-archiving. Piwowar et al. (2018) found about 18% more citations for OA overall, driven by green and hybrid OA. Gold OA articles were cited less. Others found no advantage (Lansingh & Carter, 2009). A systematic review of 134 studies found an advantage in 47.8% of them, and few studies had a low risk of bias (Langham-Putrow et al., 2021). Basson, Blanckenberg, and Prozesky (2021) found the advantage in only a few fields. C.-K. Huang et al. (2024) found that OA outputs attract more diverse citations.

Evidence for an OA altmetric advantage is mixed. Poplašen and Grgić (2017) and Patel, Vaduganathan, Bhatt, and Bonow (2018) found no significant difference in Altmetric scores between OA and non-OA articles. Holmberg, Hedman, Bowman, Didegah, and Laakso (2020) found effects that varied by discipline and platform. Taylor (2023) found that the OA advantage differs by source, with consistent gains for Mendeley and blogs but not for X coverage. Taylor (2026a) reports that the citation advantage shrinks for recent papers, while news and blog advantages stay stable. A publisher report found gold OA ahead on both measures in hybrid journals (Springer Nature, 2021a). Dental journals show a similar long-term pattern (Yu, Meng, Qin, Shen, & Hua, 2022). In *Nature Communications*, OA articles received more citations, page views and social media attention, and were downloaded for longer (Wang, Liu, Mao, & Fang, 2015). On social media, links to OA versions of articles were clicked more often than links to paywalled versions (Li, Liu, & Wang, 2021). OA articles are also more likely to be cited on Wikipedia (Yang, Shoaib, West, & Colavizza, 2024).

2.5 Research gap and hypotheses

Studies of the attention–citation link rarely ask whether OA changes its strength. A meta-analysis of 914 correlations from 111 studies found no moderator, among those it tested, that consistently changed the link (Stephen & Stahlschmidt, 2024). Poplašen and Grgić (2017) split their sample by OA but reported no correlation test. Other studies entered Altmetric scores and OA status as separate predictors of citations, without an interaction (Black, Lehane, Burns, & O'Donnell, 2018; de Oliveira Silva, Taborda, Pazzinatto, Ardern, & Barton, 2021). Two studies come closer. Hadad et al. (2025) analysed Israeli publications from 2013–2023 with Scopus and PlumX data. The link between academic impact and societal engagement was closer for OA publications and strengthened in recent years, particularly for OA. Cho and Park (2023) tested OA as a moderator of a social mention–usage–citation path in 2,522 Korean articles; the moderated mediation was significant in medicine only. Each covered a single country, and neither compared articles within journals or measured attention before citations. We address these gaps.

We test five hypotheses:

H1. Altmetric Attention Score and citation count are positively correlated.
H2. The correlation is stronger for OA articles.
H3. OA articles receive higher Altmetric scores.

H4. OA affects citations less than it affects Altmetric scores.
H5. The moderation effect of OA (H2) varies across journals and fields.

3 Data and methods

3.1 Within-journal design

Comparing an OA journal with a subscription journal confounds OA with quality standards and publication processes. We therefore compare OA and non-OA articles inside the same hybrid journal (Harnad & Brody, 2004). This design has been used to estimate the hybrid OA citation advantage (Clark et al., 2024; Dorta-González & Dorta-González, 2022), but not to compare attention–citation links. Each journal acts as its own control. Pooling journals then shows whether the OA effect is general or field-specific.

3.2 Study 1: Springer hybrid journals

We reuse the open dataset released with Springer Nature's *Going for Gold* report (Springer Nature, 2021a, 2021b). It lists 60,567 research articles in Springer hybrid journals, almost all published in 2018. For each article it gives the DOI, the Altmetric Attention Score, citations, the main discipline, the journal impact factor, a funder flag, the ranking of the first listed university, downloads on the Springer platform and the access group. The dataset marks articles as "gold" (7,660), green OA via an early version in a repository (8,350) or non-OA (44,557). The scores and citations were recorded in 2021.

In a subscription journal, an article that the authors pay to make open at publication is *hybrid OA*; Springer's dataset calls it "gold", and Unpaywall, OpenAlex and Dimensions call it hybrid. We use *hybrid OA* throughout. We compare two groups: *hybrid OA* and *non-hybrid* (green OA and non-OA together, 52,905 articles). Hybrid OA makes the version of record free on the publisher's site from the day of publication. This is the version that news, blogs and social media link to. Green copies are earlier versions in repositories, often posted later and less visible. For most early readers, a green article sits behind the same paywall as a non-OA article. Green OA also depends on authors depositing a copy, and most do not. Springer journals permit self-archiving of the accepted manuscript, yet only 16% of non-hybrid articles had a repository copy by 2021. Only 7% of the remaining non-OA articles gained one by 2026. As a robustness check we refit the main model without green articles.

On 21–22 October 2026 we retrieved each DOI from OpenAlex (Priem, Piwowar, & Orr, 2022). We took yearly citation counts, current OA status, the number of authors and the number of countries. We also took two field-normalised measures: the field-weighted citation impact (FWCI) and the citation percentile among works of the same field and year. The corresponding author's country (first author's when missing) was mapped to World Bank income groups (World Bank, 2026). 60,565 DOIs matched; the two that did not were non-OA articles. The outcome is the number of citations received in 2022–2026. Attention (2021) is thus measured before the outcome. Journals are identified by the Springer DOI prefix (1,275 journals).

3.3 Natural experiment: national OA agreements

In 2018, several countries had national agreements with Springer that paid for hybrid OA. Under the UK Springer Compact pilot (2016–2018), articles by eligible corresponding authors were published OA by default, with an opt-out at acceptance (Marques & Stone, 2020). Similar agreements covered the Netherlands, Austria and Sweden (Springer Nature, 2016). In Sweden, the OA share of eligible articles rose from about 12% to almost 100% (Olsson, Francke, Lindelöw, & Willén, 2020). For these authors, hybrid OA followed the agreement rather than the author's choice or ability to pay. Earlier Springer pilot agreements with single institutions and the Dutch university consortium served as a natural experiment for economics and mathematics journals (Mueller-Langer & Watt, 2018). That study found no hybrid OA citation benefit overall, but a positive effect for articles without a preprint or postprint. We extend this design to national agreements in five countries, to all fields, and to attention and downloads as well as citations. A related design treats journals' entry into a transformative journal programme as a policy shock (Ye, Yu, & Chen, 2026).

We define agreement countries from the data: corresponding-author countries with at least 300 articles and a hybrid OA share of at least 75%. These are the Netherlands, Sweden, Poland, Austria and the UK. Poland also had a national agreement with Springer, but we could not confirm that it covered 2018, so we repeat the analysis without it. The comparison group is all other European countries. Finland, with a hybrid OA share of 32%, is in neither group. We compare the two groups within journals in two ways. A reduced-form PPML model regresses citations on agreement-country status. An instrumental-variable (two-stage least squares) model uses agreement-country status as an instrument for hybrid OA. The IV estimate assumes that agreement-country status affects citations only through hybrid OA. We probe this with a placebo: among non-hybrid articles, agreement-country status should not predict citations. Because this check conditions on access status, it is supportive rather than conclusive. Treatment varies by country, so we also report standard errors clustered by country and a randomisation test: 1,000 times, five European countries drawn at random receive placebo agreement status, and we compare the observed effect with the placebo distribution. A further check restricts the comparison group to high-income Western European countries.

3.4 Study 2: *Nature* 2015–2022

We listed all *Nature* items with research-type DOIs published in 2015–2022 from Crossref, after removing corrections. Europe PMC publication types separate research articles from News & Views pieces and reviews. OpenAlex gives citations, OA status, field, authors and countries; Europe PMC gives NIH funding. Data were collected on 21–22 October 2026.

Nature had no paid OA option until January 2021. Before then, OA arose mostly after publication, through self-archiving after a six-month embargo or free-to-read publisher copies. A few articles (4%) carried an open licence from publication, for example CC BY-NC-SA; OpenAlex classes these as hybrid. We therefore study two periods: 2015–2020, and 2021–2022 with hybrid OA available. We compare three groups: closed,

OA added later (green or bronze), and hybrid OA. We also report all OA vs closed. Models are negative binomial regressions of total citations with year, field, NIH funding and log number of authors as controls. Study 2 has no attention data. It tests how access type relates to citations in a journal that almost every institution subscribes to.

3.5 Study 3: attention sources

Study 1 has only the composite Altmetric score. To see which sources carry the hybrid OA gap, we use an Altmetric Explorer export of Colombian research output from 2019–2023 (Márquez-Bustos & Gregorio Chaviano, 2026). It gives per-source mention counts, Mendeley readers, Dimensions citations and the OA type for 25,188 articles. We keep hybrid OA and closed articles in the 625 journals that published both: 1,335 hybrid OA and 2,011 closed articles. Attention and citations were recorded at the same time, and only articles with an Altmetric record are included. We compute Spearman ρ between each source and citations, overall and within journal–year cells.

3.6 Analysis

Citation counts and Altmetric scores are highly skewed, so we use rank-based tests and count models.

1. Descriptive statistics by access group; Mann–Whitney U tests.
2. Spearman ρ between Altmetric score and later citations, by access group. A within-journal version correlates percentile ranks computed inside each journal. We repeat the test on articles with a non-zero score, since ties at zero lower ρ.
3. Fisher z tests (with the 1.06 variance factor for Spearman ρ) and a bootstrap 95% confidence interval (1,000 resamples) for $\rho_{\text{hyb}} - \rho_{\text{non-hyb}}$.
4. Poisson pseudo-maximum-likelihood (PPML) regression with journal fixed effects and journal-clustered standard errors (Santos Silva & Tenreyro, 2006):

$$\log \mathbb{E}[C_{ij}] = \beta_1 \log(1 + A_{ij}) + \beta_2 \,\text{Hyb}_{ij} + \beta_3 \,\text{Hyb}_{ij} \log(1 + A_{ij}) + \boldsymbol{\gamma}^\top \mathbf{x}_{ij} + \alpha_j, \quad (1)$$

   where C_{ij} is the 2022–2026 citation count of article i in journal j, A_{ij} its 2021 Altmetric score, $\mathbf{x}_{ij}$ the controls (log number of authors, funder flag) and α_j the journal effect. H2 corresponds to $\beta_3 > 0$. Model 2 adds $\log(1 + \text{citations to 2021})$.
5. Heterogeneity (H5): the same model by discipline, and journal-level comparison of ρ for journals with at least 20 hybrid OA and 20 non-hybrid articles.
6. Selection: exact matching of each hybrid OA article to non-hybrid articles in the same cell of journal × funder flag × author-count band (1–2, 3–4, 5–7, 8+) × university-ranking quartile × citations to 2020 (0, 1–2, 3–5, 6–10, 11+). Non-hybrid articles are weighted to the hybrid OA cell sizes. Confidence intervals come from a bootstrap over cells. Citations to 2020 may themselves reflect OA, so we repeat the matching without them.
7. Score spread: non-hybrid articles resampled (200 times) to match the hybrid OA distribution of Altmetric scores, then ρ recomputed.
8. Mechanism and prediction: partial Spearman correlations of attention and later citations, controlling for downloads or for citations to 2020; area under the ROC

curve (AUC) for identifying the top 10% of articles by later citations within each journal.

9. Journal impact factor (JIF): the dataset gives one JIF per journal. We split articles into JIF quartiles of equal size, without splitting journals, and repeat the correlation, matching and citation-advantage analyses in each. In the PPML models we add interactions of log(JIF) with hybrid OA and attention; the journal fixed effects absorb the JIF main effect.
10. Field-normalised outcomes: FWCI and citation percentile; linear models of the percentile with journal fixed effects.
11. Downloads as mediator: PPML models of later citations with and without $\log(1 + \text{downloads})$, by access group.

Analyses use Python (`scipy`, `statsmodels`, `pyfixest`). Code and derived data will be made publicly available at https://github.com/mertankarali/AltvsCite upon acceptance.

3.7 Use of generative AI

We used Claude (Anthropic), a large language model, to help write the data-collection and analysis code, run the analyses, check references against Crossref, and draft and edit the text. The authors reviewed and verified all code, results and text, and take full responsibility for the content. All analyses can be reproduced with the code and data in the repository.

4 Results

4.1 Study 1: attention and later citations in 1,275 hybrid journals

Access groups.

Hybrid OA articles received more attention than non-hybrid articles (Table 1). Two thirds of hybrid OA articles had a non-zero score, against one third of non-hybrid articles (Mann–Whitney $p < 0.001$, rank-biserial $r = 0.36$). Hybrid OA articles were also cited more in 2022–2026 (median 13 vs 8; $p < 0.001$, $r = 0.24$). By 2026, 8% of the articles that were non-OA in 2021 had become OA, mostly through repositories.

Table 1 Study 1: attention (2021) and citations by access group.

		Altmetric score (2021)			Citations, median	
Group	*N*	Mean	Median	Non-zero	to 2021	2022–2026
Hybrid OA	7,660	9.63	1	65%	6	13
Non-hybrid	52,905	2.30	0	34%	4	8
of which green OA	8,350	4.12	1	54%	4	8
of which non-OA	44,555	1.96	0	30%	4	8

Correlation by access group.

Attention in 2021 correlated with later citations in all groups (Table 2). The raw correlation was twice as strong for hybrid OA as for non-hybrid articles; robustness checks below reduce this gap. The gap remained within journals and among articles with a non-zero score. The bootstrap 95% CI for $\rho_{\text{hyb}} - \rho_{\text{non-hyb}}$ was $[0.16, 0.21]$. Higher citations come with higher attention in both groups, but the gradient is steeper for hybrid OA (Fig. 1).

Table 2 Study 1: Spearman ρ between Altmetric score (2021) and citations in 2022–2026. Fisher z compares the two groups.

Group	All articles	Within journal	Score > 0
Hybrid OA	0.378	0.234	0.342
Non-hybrid	0.192	0.128	0.220
All	0.240	0.153	–
Fisher z (hybrid OA vs non-hybrid)	16.2	–	8.1

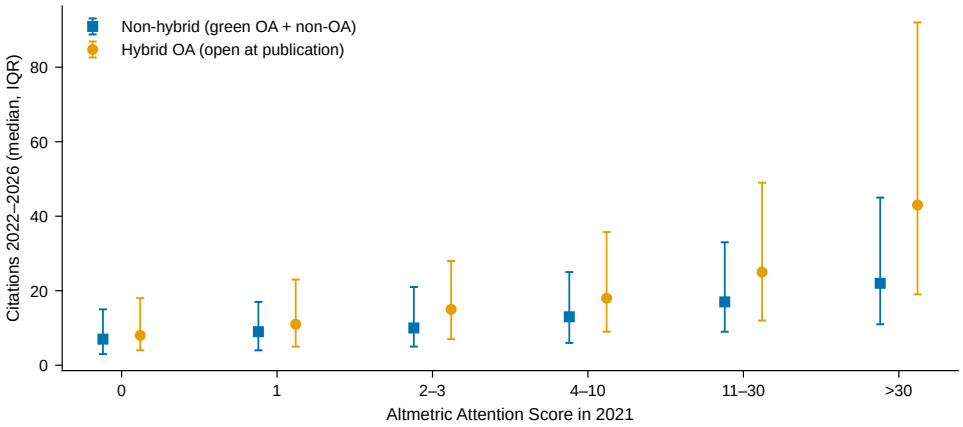


Fig. 1 Study 1: citations in 2022–2026 by Altmetric score in 2021 and access group (median and interquartile range).

Regression.

With journal fixed effects, the hybrid OA $\times$ attention interaction was positive and significant (Table 3, Model 1). A one-unit rise in $\log(1 + A)$ raised expected later citations by 30% for non-hybrid articles and by 44% for hybrid OA articles. Dropping green articles gave a slightly larger interaction (0.120, $p < 0.001$; Model 3). Adding citations received up to 2021 (Model 2) shrank all attention effects. The hybrid OA

interaction became small and non-significant. Early citations already carry most of the information that attention adds for OA articles.

Table 3 Study 1: PPML regression of citations in 2022–2026, with journal fixed effects (1,275 journals). Standard errors clustered by journal.

	Model 1		Model 2 + early citations		Model 3 green excluded	
	Coef.	SE	Coef.	SE	Coef.	SE
$\log(1 + A)$	0.263***	0.012	0.067***	0.007	0.249***	0.014
Hybrid OA	0.109*	0.046	0.070**	0.022	0.124**	0.045
Hybrid OA $\times \log(1 + A)$	0.104**	0.035	0.018	0.017	0.120***	0.035
log(authors)	0.141***	0.031	−0.007	0.013	0.137***	0.034
Funder flag	−0.023	0.017	−0.009	0.011	−0.032	0.019
log(1 + citations to 2021)			0.977***	0.014		
N		60,565		60,565		52,215

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Fields and journals.

The correlation was stronger for hybrid OA than for non-hybrid articles in 16 of the 17 disciplines with at least 100 hybrid OA articles (Fig. 2). Materials science was the exception. The gap was largest in environmental science, life sciences and earth sciences. If OA made no difference, 16 or more of 17 disciplines in the same direction would be very unlikely (sign test, $p < 0.001$). Field-specific models gave a significant hybrid OA interaction in five disciplines: environment, earth sciences, physics, philosophy and social sciences. These separate tests are underpowered; after Holm correction only philosophy remained significant. In education the interaction was negative but not significant ($p = 0.055$). Among 65 journals with at least 20 hybrid OA and 20 non-hybrid articles, ρ was higher for hybrid OA in 69% (median difference 0.10; Wilcoxon $p < 0.001$).

Citations over time.

The citation lead of hybrid OA articles grew with age (Fig. 3). Hybrid OA articles received 1.5 times as many citations per year as non-hybrid articles in 2018–2019, 1.8 times in 2021–2023 and 1.9 times in 2024–2025. We found no sign that the advantage fades.

Selection and score spread.

Hybrid OA articles differ from others. They are more often funded (59% vs 52%), have larger teams (mean 5.7 vs 4.6 authors), come from higher-ranked universities (median rank 143 vs 401) and more often have a non-zero score. Both checks reduced the gap to about a third of its raw size or a little more (Table 4). Exact matching kept 3,553

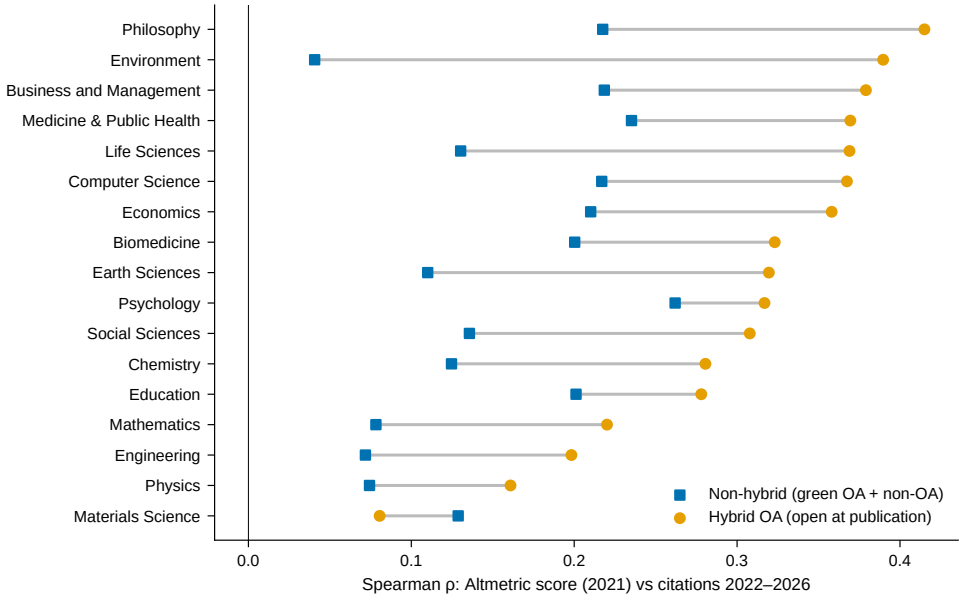


Fig. 2 Study 1: Spearman ρ between Altmetric score (2021) and citations in 2022–2026, by discipline, for hybrid OA and non-hybrid articles. Disciplines with at least 100 hybrid OA articles.

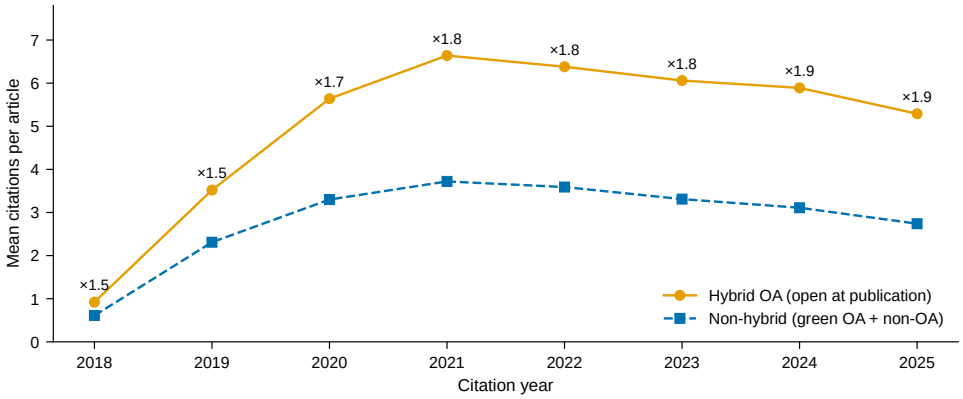


Fig. 3 Study 1: mean citations per article by citation year. Labels give the hybrid OA / non-hybrid ratio. 2026 is incomplete and omitted.

hybrid OA articles and 7,047 controls in 2,705 cells. Citations to 2020 were balanced (means 10.0 and 9.3). The remaining gap was 0.06 (95% CI 0.03–0.10). This estimate describes the hybrid OA articles that had comparable non-hybrid articles in the same journal. Without matching on citations to 2020, which may themselves reflect OA, 5,613 hybrid OA articles were matched and the gap was 0.11 (0.08–0.14). The 0.06

is therefore a conservative estimate. Giving non-hybrid articles the same score spread gave a gap of 0.07.

Table 4 Study 1: Spearman ρ between Altmetric score (2021) and citations in 2022–2026 under robustness checks.

Check	Hybrid OA	Non-hybrid	Gap
Raw	0.378	0.192	0.19
Exact matching	0.380	0.320	0.06 (0.03–0.10)
without citations to 2020	0.359	0.250	0.11 (0.08–0.14)
Equal score spread (resampled)	0.378	0.304	0.07
Partial ρ | citations to 2020	0.159	0.105	0.05
Partial ρ | downloads	0.087	−0.031	0.12

Mechanism: downloads.

Attention was linked to downloads more strongly for hybrid OA articles ($\rho = 0.50$) than for non-hybrid articles ($\rho = 0.36$). Hybrid OA articles were also downloaded five times as often (median 1,730 vs 332). Downloads predicted later citations well in both groups ($\rho = 0.64$ and 0.60). With downloads controlled, the attention–citation link almost disappeared (Table 4). In PPML models with journal fixed effects, adding downloads reduced the attention coefficient from 0.38 to 0.01 for hybrid OA articles and from 0.25 to −0.01 for non-hybrid articles. Each unit of $\log(1 + A)$ raised $\log(1 +$ downloads) by 0.26 for hybrid OA and 0.19 for non-hybrid articles. This is consistent with attention leading to citations through reading, with free access making that step easier. Downloads were recorded at the same time as attention, however, so the order is not shown. Downloads also do not explain the whole hybrid OA difference: with downloads controlled, the partial correlation of attention and citations was still higher for hybrid OA articles (Table 4).

Beyond early citations.

Citations to 2020 were recorded before the 2021 scores. With them controlled, attention still predicted later citations, slightly more for hybrid OA articles (partial ρ 0.16 vs 0.11).

Identifying top-cited papers.

Attention was a weak signal of which articles would be in the top 10% of their journal by later citations: AUC 0.61 for hybrid OA and 0.54 for non-hybrid articles. Citations to 2020 did much better (AUC 0.83 in both groups), and downloads were in between (0.75 and 0.73).

Journal impact factor.

Hybrid OA was more common in higher-JIF journals: 10% of articles in the lowest quartile and 19% in the highest (journal-level $\rho = 0.27$). The raw correlation gap appeared in every quartile (Table 5). After matching, it was larger in the lower half (0.10 and 0.12) than in the upper half (0.02 and 0.05), but the intervals were wide. In the pooled model, the hybrid OA × attention interaction weakened as JIF rose (-0.086 per unit of log JIF, $p = 0.06$). The hybrid OA citation advantage also fell with JIF, from 1.73 in the lowest quartile to 1.36 in the highest. This decline was significant in the pooled model (-0.154 per unit of log JIF, $p = 0.02$). It implies an advantage of about 1.7 at JIF 1 and 1.1 at JIF 19, the highest value in the sample.

Table 5 Study 1 by journal impact factor quartile (equal numbers of articles; journals not split). Matched gap: hybrid OA minus matched non-hybrid Spearman ρ (cell bootstrap 95% CI). Citation RR: hybrid OA vs non-hybrid citations in 2022–2026, PPML with journal fixed effects (95% CI).

JIF	Journals	N	Hybrid	ρ_{hyb}	$\rho_{\text{non-hyb}}$	Matched gap	Citation RR
0.1–1.5	468	14,987	10%	0.37	0.17	0.10 (−0.00, 0.19)	1.73 (1.38, 2.16)
1.5–2.2	291	15,277	10%	0.26	0.13	0.12 (0.03, 0.21)	1.55 (1.38, 1.74)
2.2–2.9	266	15,142	12%	0.28	0.15	0.02 (−0.05, 0.11)	1.58 (1.30, 1.92)
2.9–19.0	250	15,159	19%	0.33	0.13	0.05 (−0.03, 0.11)	1.36 (1.24, 1.49)

Field-normalised citations.

Hybrid OA articles had higher field-normalised impact: median FWCI 1.84 vs 1.09, and 37% vs 21% in the top 10% of their field and year. Attention correlated more strongly with FWCI for hybrid OA articles ($\rho = 0.39$ vs 0.24). In a linear model of the citation percentile with journal fixed effects, hybrid OA added 3.2 percentile points and each unit of $\log(1 + A)$ added 3.0 points. Their interaction was not significant (-0.002, $p = 0.39$). On this bounded scale the moderation is not visible; it appears in rank correlations and count models.

Who publishes hybrid OA.

Hybrid OA was concentrated among well-resourced authors. It covered 19% of articles from high-income countries but 2.1% from upper-middle-income and 0.9% from lower-middle-income countries. It covered 24% of articles from the top third of universities by rank and 4.6% from the bottom third. The citation advantage of hybrid OA was larger at top-ranked universities (RR 1.53, 95% CI 1.37–1.71) than in the bottom third (1.26, 1.13–1.40), although the intervals overlap.

4.2 Natural experiment: national OA agreements

Agreement-country status shifted hybrid OA sharply: 83% of articles from the five agreement countries were hybrid OA, against 7% from other European countries (Table 6). The first stage was strong ($F = 458$ with standard errors clustered by country). Within the same journals, articles from agreement countries received 29% more

citations in 2022–2026, twice the attention and three times the downloads. Controlling for university rank reduced the citation effect only to 24%.

The placebo is consistent with the IV assumption. Among non-hybrid articles, those from agreement countries were not cited more than those from comparison countries (RR 0.95, 95% CI 0.84–1.06). The IV estimate of the effect of hybrid OA was 0.24 on log(1 + citations), about 27% more citations, close to the ordinary least-squares estimate of 0.28. Self-selection therefore inflates the simple comparison only a little. Hybrid OA raised the field-normalised citation percentile by 3 points. Results without Poland were nearly identical (citation RR 1.31; placebo 0.94). Country-level inference gave the same picture. With standard errors clustered by country, the citation RR was 1.29 (1.20–1.40), the attention RR 2.06 (1.46–2.91) and the download RR 3.03 (2.62–3.49). In the randomisation test, only 1.4% of placebo sets of five countries reached the observed citation effect. With only high-income Western European countries as comparison, the citation RR was again 1.29 (1.19–1.39), and the placebo remained null (0.96, 0.90–1.01).

The attention–citation correlation was stronger in agreement countries ($\rho = 0.35$ vs 0.24; Fisher $z = 7.4$). In the PPML model the attention × agreement interaction was positive but not significant at 5% (0.068, $p = 0.096$).

Table 6 Natural experiment: articles by corresponding authors in agreement countries (NL, SE, AT, GB, PL) vs other European countries, same journals (1,173 journals). Rate ratios (RR) from PPML with journal fixed effects; IV estimates from two-stage least squares with agreement-country status as instrument. 95% CIs in brackets.

	Agreement countries	Other Europe
Articles	6,283	10,684
Hybrid OA share	83%	7%
Share with attention > 0	62%	43%
Median citations 2022–2026	11	8
Spearman ρ (attention, later citations)	0.35	0.24
Agreement countries vs other Europe (reduced form)		
Citations, RR		1.29 [1.18, 1.42]
controlling for university rank		1.24 [1.13, 1.35]
placebo: non-hybrid articles only		0.95 [0.84, 1.06]
Altmetric score, RR		2.06 [1.73, 2.44]
Downloads, RR		3.03 [2.83, 3.24]
Effect of hybrid OA (IV; OLS for comparison)		
log(1 + citations)	0.24 [0.19, 0.29]; OLS 0.28	
log(1 + Altmetric score)	0.37 [0.33, 0.42]; OLS 0.32	
Citation percentile (0–1)	0.030 [0.022, 0.039]	

4.3 Study 2: *Nature* 2015–2022

Sample.

Of 974 *Nature* 2015 items with research-type DOIs, 151 were News & Views pieces, 38 were reviews and 8 were supplementary items. Across 2015–2022 this left 7,073 research articles.

Access groups.

Hybrid OA was rare before 2021 and became common after (Table 7). In 2015–2020, most OA articles became open later, mainly through repositories. NIH funding drove this: 41% of later-OA articles but only 3% of closed articles were NIH-funded, reflecting the PubMed Central mandate.

Table 7 Study 2: *Nature* research articles by period and access group. Rate ratios (RR) from negative binomial models of total citations with year, field, NIH funding and log number of authors.

	2015–2020		2021–2022	
Group	*N*	Median citations	*N*	Median citations
Closed	1,255	237	342	160
OA later (green, bronze)	3,663	283	1,081	149
Hybrid OA (at publication)	197	389	535	166
All OA vs closed, RR (95% CI)		0.96 (0.90–1.03)		0.87 (0.78–0.97)
Hybrid OA vs closed, RR				1.04 (0.92–1.18)
OA later vs closed, RR				0.80 (0.71–0.89)

Citations.

Without controls, OA articles from 2015–2020 were cited 11% more than closed articles. With field and funding controls, the difference vanished (RR 0.96). In 2021–2022, hybrid OA articles were cited about as often as closed articles (RR 1.04). Articles made open later were cited somewhat less (RR 0.80). Compared with all non-hybrid articles, hybrid OA articles were cited 24% more (RR 1.24, 1.13–1.36), but only because articles made open later were cited less than closed ones. In *Nature*, OA therefore brought no citation advantage over closed articles; taken together, OA articles from 2021–2022 were cited somewhat less (RR 0.87, 0.78–0.97).

4.4 Study 3: attention sources

The hybrid OA gap appeared in public attention, not in scholarly readership (Fig. 4). In journals that published both kinds of article, hybrid OA articles more often had news coverage (24% vs 10%) and blog mentions (18% vs 7%). For X, news, blogs, Facebook, Reddit, Wikipedia and Bluesky, the correlation with citations was much stronger for hybrid OA articles. Examples are X ($\rho = 0.47$ vs 0.09), news (0.45 vs 0.20)

and blogs (0.39 vs 0.10); all differences had $p < 0.001$. For policy documents the gap was smaller (0.35 vs 0.24, $p = 0.001$). The Altmetric score showed a larger gap than in Study 1 (0.51 vs 0.19). Mendeley readers were the exception: they correlated strongly with citations in both groups, somewhat more for closed articles (0.71 vs 0.77). Hybrid OA articles here were younger on average (mean publication year 2021.7 vs 2020.9). Within journal–year cells (ranks centred within cells with at least three articles of the group; 390 hybrid OA and 698 closed articles), the pattern held: Altmetric score 0.46 vs 0.21, X 0.39 vs 0.18, news 0.35 vs 0.16, blogs 0.37 vs 0.11. Mendeley again showed the reverse, more clearly (0.37 vs 0.63). With ten measures tested, all differences remain significant after Holm correction.

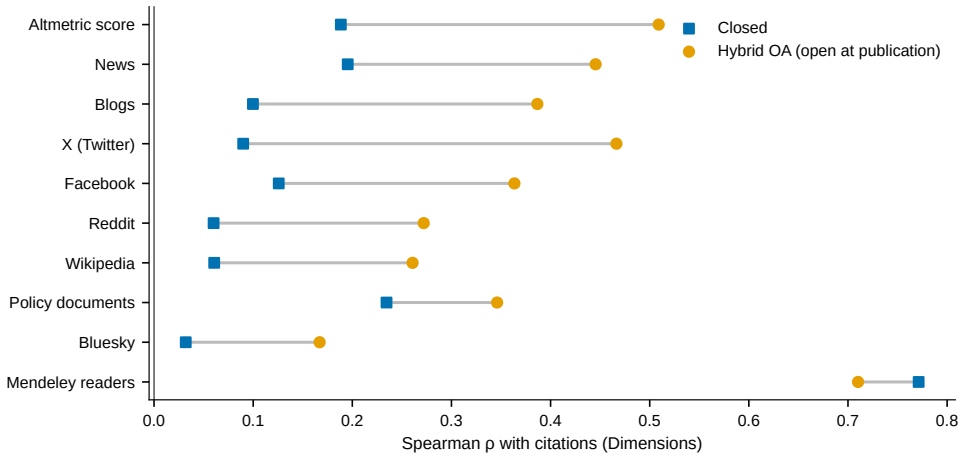


Fig. 4 Study 3: Spearman ρ between each attention source and citations, hybrid OA vs closed articles in 625 journals that published both (Colombian research output 2019–2023).

5 Discussion

Attention and citations were positively but weakly to moderately correlated, as in most earlier work (Costas et al., 2015; W. Huang et al., 2018; Thelwall & Nevill, 2018). Our main finding is that OA status moderates this link. Across 1,275 hybrid journals, attention predicted later citations better for hybrid OA articles than for non-hybrid articles. The pattern held within journals and in almost every discipline. H1, H2 and H5 are supported. The effect is modest. The raw gap in ρ was 0.19, but roughly 60–70% of it came from selection and from the wider spread of attention among hybrid OA articles. After matching, a gap of 0.06 remained, or 0.11 without matching on early citations. Most of the moderation evidence is observational. Once citations up to 2021 are controlled, the interaction is small.

The natural experiment strengthens a causal reading of the OA effects. Where national agreements made hybrid OA the default, OA depended much less on author choice or funding, although authors could opt out and 17% of articles were not hybrid

OA. Articles from these countries gained twice the attention, three times the downloads and 29% more citations, while their non-hybrid articles showed no advantage. These effects held with country-level inference. The IV and simple estimates were close. Earlier work warned that self-selection may explain much of the OA citation advantage (Basson et al., 2021; Langham-Putrow et al., 2021). In this setting it explains little. Our citation effect is larger than most earlier causal estimates. Randomised trials found more downloads but no citation gain within one to three years (Davis, 2011; Davis, Lewenstein, Simon, Booth, & Connolly, 2008). An instrumental-variable study of *PNAS* (Gaulé & Maystre, 2011) and a natural experiment with earlier Springer agreements (Mueller-Langer & Watt, 2018) found no significant citation benefit once selection was addressed. A panel of journals gave about 8% (McCabe & Snyder, 2014), and the NIH public access mandate a modest effect (Staudt, 2020). Three features of our setting may explain the difference. The citation window is longer, four to eight years after publication. Most journals are specialist journals, where subscriptions are less common. And the comparison group is mostly closed; Mueller-Langer and Watt (2018) also found a positive effect for articles without a free earlier version. Our download effect agrees with the trials. The attention–citation link was also stronger in agreement countries, though the interaction was only marginally significant. The natural experiment thus supports causal effects of OA on the level of attention and citations more firmly than on the link between them.

Why is the link stronger for hybrid OA? When the full text is free, the people who share a paper and the people who later cite it are more likely to have read it. Attention then reflects use, not only visibility. The download data support this reading. Attention turned into downloads more strongly when the article was free, and downloads carried most of the link between attention and citations. This fits earlier evidence that OA links on social media are clicked more often (Li et al., 2021), that OA raises downloads (Davis et al., 2008), and that early downloads predict later citations (Brody, Harnad, & Carr, 2006). Cho and Park (2023) found a similar usage pathway in medicine. Green copies do not give this benefit to most early readers: they are earlier versions, often posted later, and links from news and social media point to the publisher's page. Green OA also relies on authors to deposit a copy, and 84% of non-hybrid articles had none in 2021. This is why we group green OA with non-OA articles. Excluding green articles leaves the result unchanged.

Study 3 shows which attention is affected. Public attention (news, blogs, X, Facebook, Reddit, Wikipedia) correlated with citations far more strongly for hybrid OA articles. Mendeley readership did not. These data are cross-sectional, so they show where the difference lies, not its timing. Mendeley readers are mostly PhD students, postdocs and other researchers (Mohammadi, Thelwall, Haustein, & Larivière, 2015). They save papers they can read, so readership is close to citation regardless of access. Earlier work compared the level of each source between OA and non-OA articles (Holmberg et al., 2020; Taylor, 2023, 2026a); we compare how each source relates to later citations. Public mentions, in contrast, reach readers outside subscribing institutions. Only when the article is free can that attention turn into reading and, later, citation. This matches the download results of Study 1.

Early citations add an important nuance. Once citations up to 2021 are controlled, the hybrid OA interaction is small. With citations to 2020 controlled, attention still adds a little, slightly more for hybrid OA articles. Early citations and early attention largely carry the same information. Attention was also a weak way to spot future top-cited papers (AUC 0.54–0.61), far below early citations (0.83). Altmetric scores are thus a somewhat better proxy for hybrid OA articles, but a poor substitute for citations in assessment.

Hybrid OA articles also received more attention and more citations (H3 supported in Study 1). OA raised attention more than citations: in the natural experiment, the attention RR was 2.06 and the citation RR 1.29 (H4 supported). Their citation lead grew over eight years. This agrees with recent large studies (Clark et al., 2024; Dorta-González & Dorta-González, 2022; Springer Nature, 2021a; Taylor, 2023) and differs from earlier small samples (Patel et al., 2018; Poplašen & Grgić, 2017). Taylor (2026a) reports a shrinking advantage for recent papers; our cohort is older and shows the opposite.

Study 2 shows where the citation advantage stops. In *Nature*, OA brought no citation advantage over closed articles once field and funding were controlled, before or after hybrid OA became available. Articles made open later were even cited somewhat less. Almost every research institution subscribes to *Nature*, so free access adds few new readers. In specialist journals, subscriptions are less common and free access matters more. The impact factor results in Study 1 point the same way: the hybrid OA citation advantage shrank as JIF rose, and the fitted trend implies only a small advantage at the top of the range, where journals are few. A study of all journal articles in Dimensions also found the largest OA advantages in lower-tier journals (Taylor, 2026b). A panel of whole journals that changed access model found the opposite: gains concentrated in top-ranked journals and losses in bottom-ranked ones (McCabe & Snyder, 2014). That study compared whole journals over time, not articles within the same journal. By contrast with our *Nature* results, a simple comparison in *Nature Communications* during its hybrid period found more citations for OA articles (Wang et al., 2015). *Nature*, with a far higher JIF, fits this trend, although it lies well beyond the range of the Study 1 journals. The *Nature* data also show how self-selection can create an apparent advantage. Before 2021, OA arose after publication and mostly followed NIH funding. The raw 11% advantage disappeared with controls. This is a known problem for OA citation studies (Basson et al., 2021; Langham-Putrow et al., 2021).

The benefits of hybrid OA are unevenly shared. Hybrid OA was common among authors at top-ranked universities and in high-income countries, and rare elsewhere. Authors at top-ranked universities also tended to gain more citations from it. This agrees with earlier work. In Springer Nature journals, country income level was among the strongest predictors of hybrid OA (Momeni, Dietze, Mayr, Biesenbender, & Peters, 2023). In the United States, authors of APC-funded OA articles are more often senior and at prestigious institutions (Olejniczak & Wilson, 2020). APC levels are stratified by country and institutional resources (Klebel & Ross-Hellauer, 2023), and higher-ranked institutions both produce and cite more OA work (Pride, Cancellieri, & Knoth, 2022). Our data show that the same gradient shapes who gains attention and citations from OA within the same journals. Article processing charges and national agreements

thus channel the attention and citation benefits of OA to authors who are already well resourced. The natural experiment shows that agreements can extend these benefits to all authors in a country, but only in countries that can afford them.

Limitations.

Study 1 covers one publisher and mostly specialist journals, where median attention is low. Its scores were recorded once, in 2021, and Altmetric scores change over time (Arroyo-Machado & Torres-Salinas, 2024). OA status is observed, not assigned; authors choose hybrid OA, often because funders pay. Journal fixed effects remove journal-level differences, but not article-level selection. The JIF is a single value per journal from the dataset, and only 8 of the 1,275 journals had a JIF above 10. Attention data cover Studies 1 and 3; *Nature* has no current Altmetric scores in our data. The natural experiment assumes that agreement countries differ from other European countries only through hybrid OA; the placebo supports this but cannot rule out every difference. It also covers one publication year. Study 3 measures attention and citations at the same time, includes only articles with an Altmetric record, and comes from one country's research output. The field-normalised measures are OpenAlex's and may differ from those of other databases. Income groups follow the current World Bank classification, not that of 2018. The citation window includes part of 2026. Downloads and attention were recorded at the same time, so the mediation analysis cannot establish order. Attention can be raised by self-promotion, so its value as a signal may fall as it is used more in evaluation.

6 Conclusion

Digital transformation calls for recognising new forms of academic output (Pearce, Weller, Scanlon, & Kinsley, 2010). We find that online attention is a better signal of later citations for hybrid OA articles than for other articles. This holds within journals and across fields. The difference is modest once selection is accounted for. It is consistent with a reading pathway: attention goes with more downloads when the article is free. A natural experiment based on national OA agreements points to a causal OA effect on attention, downloads and citations; the stronger link itself rests on observational evidence. The difference lies in public attention, not in scholarly readership. Attention remains a weak predictor of top-cited papers compared with early citations. If Altmetric scores are used in research assessment, their meaning depends on access status. Evaluations that pool hybrid OA and other work may over- or under-rate attention as a signal.

The benefits of OA also concentrate among well-resourced authors, which matters for policy on article processing charges and national agreements. Future work should test predictive designs with per-source attention data, add further publishers, and track how the link changes as platforms change.

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Ethics approval and consent. Not applicable. The study uses publicly available bibliographic and altmetric data and involves no human participants.

Data availability. Study 1 uses the open dataset released with Springer Nature's *Going for Gold* report (figshare, https://doi.org/10.6084/m9.figshare.16860238, CC BY 4.0). Citation data come from OpenAlex (CC0), and article lists and publication types from Crossref and Europe PMC. Study 3 uses an Altmetric export of Colombian research output (Zenodo, https://doi.org/10.5281/zenodo.23198885, CC BY 4.0), which includes Dimensions citation counts. Country income groups come from the World Bank. The merged analysis tables will be made publicly available at https://github.com/mertankarali/AltvsCite upon acceptance and are available to editors and reviewers on request.

Code availability. All data-collection and analysis code will be made publicly available at https://github.com/mertankarali/AltvsCite upon acceptance. It is available to editors and reviewers on request.

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