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Measuring Impact in Open Access Research: An Altmetric and Citation Analysis

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Abstract

This study investigates the altmetric performance and citation trends of highly cited open access (OA) publications, shedding light on the interplay between online metrics and scholarly impact. Utilising data from Dimensions and Scopus databases, a cohort of 25 influential OA publications was selected from a pool of over 44 million publications. The selected articles, authored by 83 individuals from 11 countries and 45 organisations, displayed significant multi-author collaboration. These publications collectively cited 917 external sources and garnered over 1.6 million citations each from both Dimensions and Scopus databases.

Temporal analysis revealed publication trends spanning from 1951 to 2018, with articles, conference papers and reviews constituting the most prevalent document types. A comprehensive survey of source journals showcased diverse disciplinary origins. Notably, four standout publications – “Protein Measurement with the Folin Phenol Reagent,” “Deep Residual Learning for Image Recognition,” “Density-functional thermochemistry. III. “The role of exact exchange”, and “Development of the Colle-Salvetti correlation-energy formula into a functional of the electron density” – amassed over 80,000 citations each, affirming their significant impact.

The correlation between altmetric metrics and Scopus citations was examined, revealing mixed associations. Higher view counts were linked to increased citations, underlining the role of initial visibility. However, usage and captures metrics displayed no substantial correlation with citations. In contrast, mentions and social media metrics demonstrated a significant positive relationship with citations, underscoring the influence of social media engagement on research dissemination.

Overall, the study underlines the significance of social media in driving research impact and dissemination. It underscores the importance of OA publishing and social media engagement as influential tools for amplifying research visibility.

Keywords: Altmetric Performance, Open Access, Highly Cited Publications, Dimensions Database, Scopus Database, Online Metrics, Citation Advantage

Introduction

The dissemination of open access (OA) scholarly content through e-media has extensively incremented the panorama of scientific literary texts for academic publishing and thus stimulated the rise of alternative metrics to measure the article impact. The involuntary budget constraints have unzipped the preference of the distribution of publications in diverse formats like print only, print plus online and online only. Over recent years, the upward trend towards economic and inexpensive incentive has been observed for online and electronic media to publish, disseminate and rapidly access scientific literature remotely. Here emerged the concept of OA publications. The marketability of OA publications is attributed to the fact that the scientific literary text of the scholarly community has become more discernible and is freely and widely accessible on Internet for scholars and non-scholars.

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Formerly, only academicians at HEIs had an easy access to print journal literature subscribed by their institutions. Conversely, the beginning of 21st century has witnessed that OA movement has strengthened free online access to scholarly publications, thus augmenting the full-text downloads of research articles across the global community.

The escalation of OA publishing enables research findings to reach a broader and more diverse audience, transcending the confines of academia thus overcoming the barriers of traditional subscription-based models. This silent transposition from traditional citation based measurement metrics to online metrics has fostered the emergence of an alternate metrics called 'altmetrics'. It is most sought-after in the midst of scientific communities as it switches the impact of authors' productivity from journal level metrics to altmetrics.

Researchers have increased the visibility of their publications by contributing, participating and maintaining their profile on academic social networking websites (ASNs) such as Research Gate, Academia.edu, Google Scholar, etc. Their participation in online discussion forums, peer to peer conversations related to their research interests downloads, views, peer-review and citations along with accessibility of research output to global academicians has further enhanced the concept of altmetrics measurement of a published paper. Apropos, Public Library of Science (PLOS), an OA publisher is the trailblazer of altmetrics in their OA journals.

Since ages, citation analysis has been the most accepted and preferred indicator of scholarly influence to evaluate the scientific validity of articles published in journals (Waltman, 2016). Social media and academic social networking websites (ASNs) has become nucleus for disseminating information and fostering discussions. The surfacing of a multitude of cost-effective ASNs, have opened up diverse opportunities for academicia and scholars to share their contributions and academic achievements with other fellow academicians over the globe (Fekete & Haffner, 2019). Subsequently, ASNs became instrumental in nurturing the comprehensive sharing of academic accomplishments, and comprehend the variegated evaluation of scientific research. It was with this backdrop that the concept of altmetrics was materialised. Altmetrics tender all-inclusive perception on research impact as it has transformed the relationship between conventional citations evaluation method with amalgamation of attributes of metrics and academic social network information being of paramount interest to the scholarly community.

Numerous investigations have been conducted regarding citation analysis of OA publications, involving researchers such as Hajjem et al. (2005), Zhang (2006), Norris (2008), Davis (2009), Xia et al. (2010), Gargouri et al. (2010), McCabe and Snyder (2014) and Langham-Putrow et al. (2021). However, the exploration of alternative metrics for OA publications, as seen in the works of Alhoori et al. (2014), Erdt et al. (2018), Holmberg et al. (2020) and Vadhera et al. (2024) remains a less studied yet increasingly significant realm of inquiry for scholars, educators and researchers, in comparison to the realm of citation analysis of OA publications. This current study aims to explore a wider range of online metrics, covering both citation and altmetrics aspects, within the realm of OA articles.

The research is organised into six sections. It commences with the introduction, followed by a literature review in the second section. The third section presents the methodology, while the fourth section explores the study's findings. The fifth part includes the conclusion, limitations and prospects for future research.

Review of Literature

Numerous research studies investigated the citation advantage of OA articles compared to Non-Open Access (NOA) articles in various disciplines. Hajjem et al. (2005) found that OA articles generally received more citations, with an advantage ranging from 36% to 172% depending on the discipline and year. Zhang (2006) explored the use of web citations to assess the scholarly influence of journals and found that an OA journal had a higher proportion of citations from non-authoritative sources, indicating broader impact beyond the research community. Eysenbach (2006) discovered that OA articles were cited twice as often as NOA articles in the first 4–10 months after publication. Norris (2008) observed disciplinary differences in the citation advantage of OA articles across fields like ecology, applied mathematics, sociology and economics.

Davis (2009) investigated the impact of open-access publication on article citations in biology and medicine, finding a modest yet noteworthy 17% increase in citations in certain journals. Xia et al. (2010) found a positive correlation between multiple OA availability and citation count, while Gargouri et al. (2010) reported that OA articles were not subject to a quality bias, showing a high OA citation advantage for both self-selected and mandatory self-archiving. McCabe and Snyder (2014) found an average OA citation advantage of 8%, varying based on content quality. Finally, Langham-Putrow et al. (2021) conducted a systematic review, indicating that studies across multiple disciplines were more likely to support the existence of an OA citation advantage in subsets and less likely to conclude that it did not exist.

Several studies have explored the impact of social media on research dissemination. Shuai et al. (2012) discovered a correlation between the number of tweets referencing preprints on arXiv.org and the number of downloads and early citations. Allen et al. (2013) posted PLOS ONE articles on various social media platforms, finding that research dissemination through these channels increased views and downloads. Haustein et al. (2014) observed that articles by bibliometricians had higher coverage and readership on Mendeley compared to CiteULike. Shema et al. (2014) found that articles cited on blogs received more citations. Alhoori et al. (2015) investigated altmetrics differences between OA and NOA articles, noting that OA articles tended to receive higher altmetrics, although some influential factors played a role in this discrepancy. Huang et al. (2018) examined the relationship between Altmetric Attention Scores (AAS) and Web of Science citations, finding significant positive correlations between the two. De Filippo and Sanz-Casado (2018) explored the impact and visibility of prestigious international scientific publications across three social science disciplines, with tweets being the most common type of mentions. Papers with social media mentions had higher citation rates. Holmberg et al. (2020) investigated the OA altmetrics advantage, observing disciplinary and platform-specific differences in the advantage. Araujo et al. (2021) examined the associations between publishing journal and article variables and altmetric scores, noting several factors influencing these scores. Vadhera et al. (2024) focused on the relationship between OA publishing and social media impact, discovering that OA articles generally had higher altmetric scores and citation rates compared to NOA articles. The study also looked into the factors associated with higher altmetric scores in this context. Overall, previous research has mostly focused on citation metrics rather than the altmetrics advantage of OA articles. The current study aims to aims to explore both aspects using a wider range of online metrics.

Methodology

In this study, all the publications under analysis were obtained from the Dimensions database. On 7th June, 2023, a search was conducted in the Dimensions bibliographic database under the “All Open Access Publications” category. The initial search yielded a substantial total of 44,486,768 publications. The process of data extraction is depicted in Fig. 1.

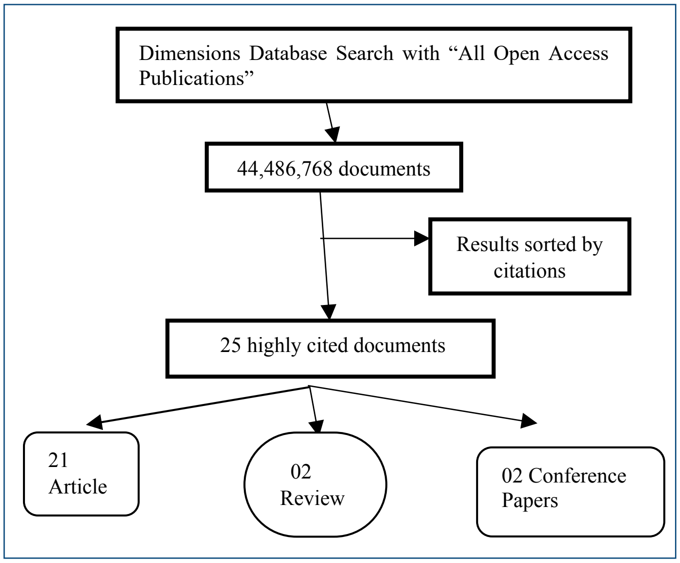


Fig. 1: Flow Chart Showing Data Extraction Process from Dimension Database

Subsequently, these results were sorted based on the number of citations, and a sample of 25 highly cited publications was chosen for further examination. To proceed with the analysis, these selected publications were exported from the Dimensions database in CSV file format. In order to gather information on the views count of each publication, the Scopus database was utilised. Additionally, data pertaining to usage, captures, mentions, social media activity and citations were collected from the Scopus, Plum Analytics Categories databases. “Plum Analytics Categories database is one of the most complete categories for altmetrics in which five indicators including usage, captures, mentions, social media and citations are presented" (Wong & Vital, 2017). Furthermore, the AAS of the publications was obtained from the Dimensions database. "Dimensions complements traditional metrics by partnering with altmetric to leverage their alternative metrics or "altmetrics" data to reveal the amount of attention an individual article has received" (Mouratidis, 2019).

Table 1: Coverage of Altmetrics for Highly Cited Open Access Publications in Our Dataset

Alternative Metrics	*Number of Publications*	*% Proportion*
Views count	25	100
Usage	22	88
Captures	25	100
Mentions	25	100
Social media	25	100
Citation	25	100
Altmetric attention score	25	100

Findings

Descriptive Statistics

The data presented in Table 2 showcases a collection of 25 publications authored by 83 individuals from 11 different countries, representing 45 organisations. Among the publications, 5 were single-authored, while the remaining 20 were multi-authored, indicating a significant level of collaboration. The publications collectively reference 917 external sources, reflecting thorough research and utilisation of existing knowledge. Furthermore, the collection has garnered significant attention, with 1,680,523 citations recorded in the Dimensions database and 1,625,327 citations in the Scopus database, emphasising their impact within the academic community.

Table 2: Overview of Sample Characteristics

Criteria	*Quantity*	
Total publications	25	
Total authors	83	
Number of single-authored publications	5	
Number of multi-authored publications	20	
Number of organizations represented	45	
Number of countries represented	11	
Total cited references	917	
Citations	Dimensions	Scopus
	1680523	1625327

Performance Analysis

Distribution of Documents Per Year

Table 3 and Fig. 2 illustrate the distribution of publications across different years, spanning from 1951 to 2018. In the earlier years, there is a sparse representation with only one or two publications per year until the late 20th century. From the mid-2010s onwards, there appears to be a noticeable increase in the number of publications, particularly in 2015 with four publications. However, the trend generally shows fluctuating patterns with no clear linear progression over time. This suggests potential shifts in research focus or productivity within the field being studied.

Table 3: Distribution of Documents Per Year

Year of Publication	*Number of Publications*
1951	1
1965	2
1977	2
1979	1
1986	1
1987	1
1988	1
1994	2
1997	1
2001	1
2003	1
2004	1
2007	1
2009	1
2011	1
2014	1
2015	4
2016	1
2018	1

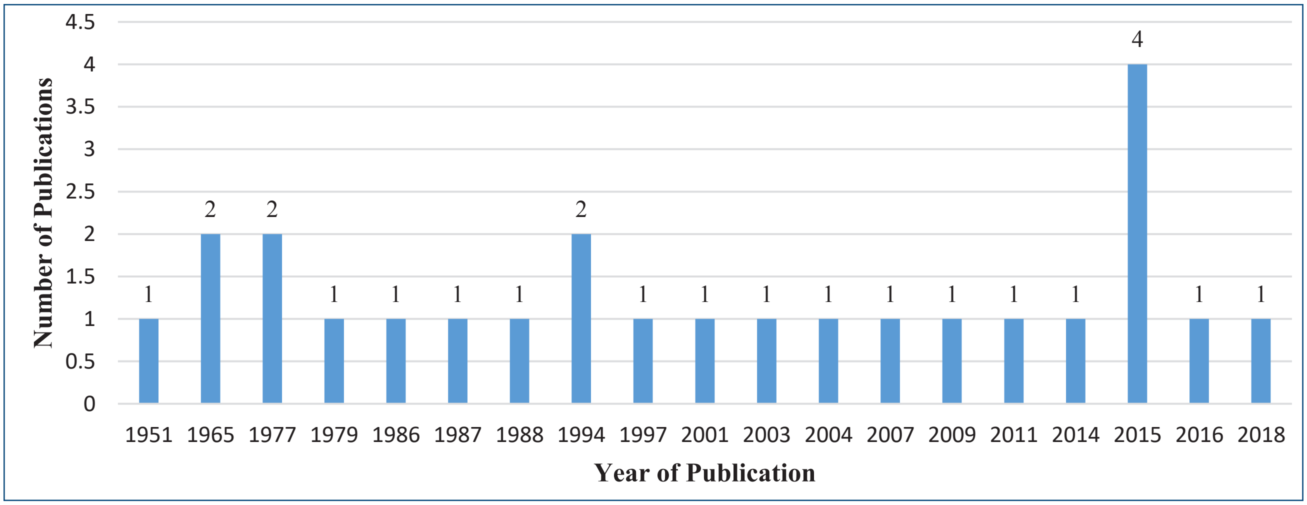


Fig. 2: Distribution of Documents Per Year

Document Type

Table 4 and Fig. 3 provide a breakdown of the number of documents based on their types. The data shows that there are 21 articles, two conference papers and two reviews. This distribution clearly illustrates that articles are the most prevalent document type, potentially encompassing research papers and academic publications covering diverse subjects. Additionally, there are a smaller number of conference papers and reviews, which likely represent contributions presented at conferences or critical assessments of previously published works, respectively. Overall, the table and figure emphasise the dominance of articles as the primary form of publication among the listed documents.

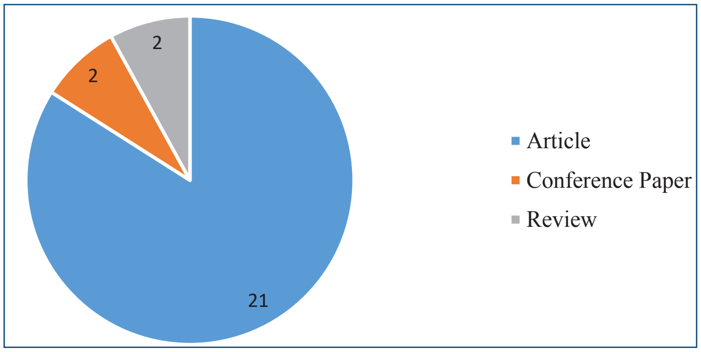


Fig. 3: Document Type

Table 4: Document Type

Document Type	*No. of Documents*
Article	21
Conference Paper	2
Review	2

Most Productive Sources

Table 5 and Fig. 4 shows the most prolific journals based on the number of publications. The data indicates that there is a diverse range of sources, including journals from different disciplines like biology, chemistry, computer science, statistics, medicine and more. Most of the sources have only one publication listed, suggesting a diverse set of single publications across various scientific domains. However, a few sources have multiple publications associated with them, such as "Physical Review B" and "Proceedings of the National Academy of Sciences of the United States of America," each having two publications. This could indicate that these sources are relatively more influential or popular in their respective fields, leading to multiple papers being published in them. Overall, both the table and the figure showcase the variety of scientific publications from different reputable sources, providing a glimpse of the diverse research being conducted across various domains.

Table 5: Most Productive Sources

Source Title	*No. of Publications*
Journal of Biological Chemistry	1
Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition	1
The Journal of Chemical Physics	1
Physical Review B	2
Acta Crystallographica Section A: Foundations and advances	1
Machine Learning	1
Proceedings of the National Academy of Sciences of the United States of America	2
Journal of Personality and Social Psychology	1
Nucleic Acids Research	1
CA: A Cancer Journal for Clinicians	1
Information and Control	1
Nucleic Acids Research	1
Biometrics	1
Science	1
Journal of Statistical Software	1
Molecular Biology and Evolution	1
Physical Review	1
PLoS Medicine	1
Cell	1
Genome Biology	1
Lecture Notes in Computer Science	1
The BMJ	1
Bioinformatics	1

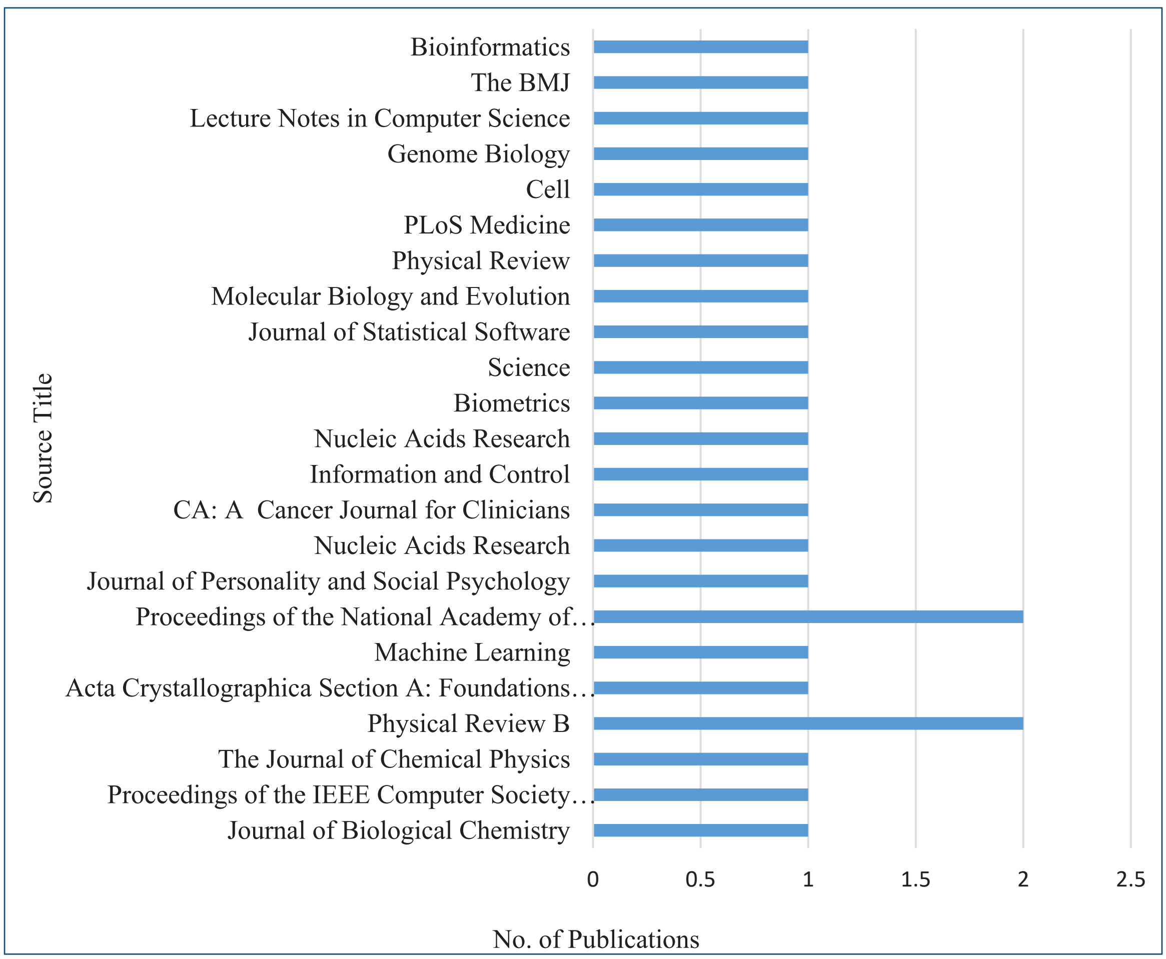


Fig. 4: Most Productive Sources

Most Productive Countries

The Table 6 and Fig. 5 present the number of scientific publications from different countries. The United States leads with the highest number of publications, with 15 scientific papers. Following the United States, there are several other countries with notable publication contributions, such as Canada with three publications, Germany and Switzerland with four publications each, and the United Kingdom with five publications. Additionally, there are a few countries represented with a single publication each, including France, Russia and China. Overall, these visual representations highlight the research productivity of various countries, showcasing their respective contributions to the global scientific community.

Table 6: Most Productive Countries

Country	*No. of Publications*
United States	15
Canada	3
Germany	4
United Kingdom	5
Switzerland	4
France	1
Russia	1
China	1

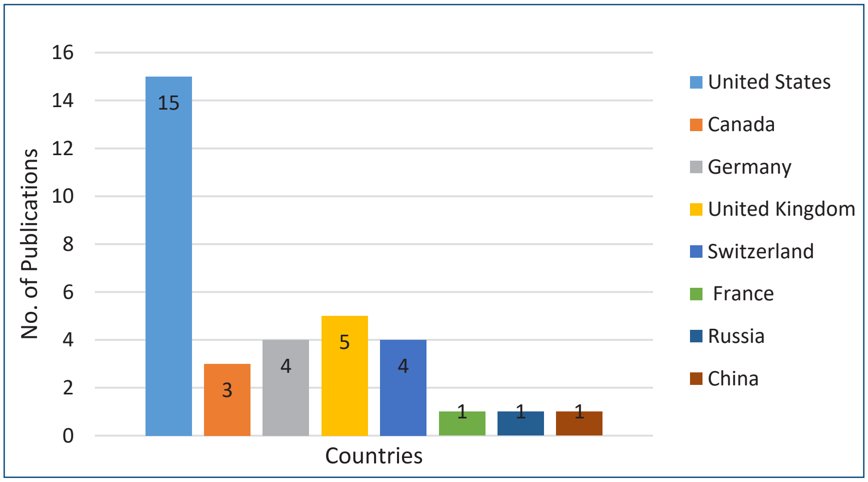


Fig. 5: Most Productive Countries

Ranking Open Access Publications

Table 7 shows the characteristics of 25 most highly cited OA publications including publication title, field citation ratio, relative citation ratio, major citing research category, recent citations and citations in Dimensions database. As shown in Table 7 and Fig. 6, all OA publications possess over 41,000 citations. Among the publications, "Protein Measurement with the Folin Phenol Reagent," "Deep Residual Learning for Image Recognition" and "Density-functional thermochemistry. III. The role of exact exchange" with 270,145, 106,947 and 87,097 citations are ranked first, second and third, respectively. About 18% of its citations have been received in the past two years.

Another aspect to highlight in this ranking is citing research categories. Research in one subject may be applicable to other areas. Table 7 shows the research fields finding these publications relevant, based on a simple count of the subject areas of the publications citing these. It is clear from the table that Biological Sciences, Chemical Sciences and Biomedical and Clinical Sciences are the primary research categories citing the research output. A significant portion (76%) of the publications have been referenced by studies falling under these subject areas.

Table 7: Citation Metrics of Notable Research Papers in Dimensions Database

Rank	Title	Dimensions Metrics					
		Citations	Recent Citations	Field Citation Ratio	Relative Citation Ratio	Major Citing Research Category	(%)
1	Protein Measurement with the Folin Phenol Reagent	270145	7377	n/a	n/a	Biological Sciences	(42.85)
2	Deep Residual Learning for Image Recognition	106947	66395	n/a	25559.75	Information and Computing Sciences	(63.38)
3	Density-functional thermo-chemistry. III. The role of exact exchange	87097	10550	n/a	n/a	Chemical Sciences	(79.32)
4	Development of the Colle-Salvetti correlation-energy formula into a functional of the electron density	82828	10673	1269.81	n/a	Chemical Sciences	(79.29)
5	A short history of SHELX	78830	6482	1411.39	11805.06	Chemical Sciences	(93.19)
6	Random Forests	68727	27895	n/a	12429.15	Information and Computing Sciences	(27.99)
7	DNA sequencing with chain-terminating inhibitors	62290	1223	n/a	n/a	Biological Sciences	(69.84)
8	The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations	60911	10263	853.74	n/a	Psychology	(30.54)
9	Gapped BLAST and PSI-BLAST: A new generation of protein database search programs	60159	5243	1313.3	n/a	Biological Sciences	(72.79)
10	Projector augmented-wave method	60058	18265	466.41	n/a	Chemical Sciences	(40.44)
11	Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries	59477	35460	3611.92	14220.75	Biomedical and Clinical Sciences	(65.26)
12	Fuzzy sets	54194	9420	n/a	n/a	Information and Computing Sciences	(48.03)
13	CLUSTAL W: Improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice	53571	3620	1278.8	n/a	Biological Sciences	(72.44)

Rank	*Title*	*Dimensions Metrics*					
		Citations	*Recent Citations*	*Field Citation Ratio*	*Relative Citation Ratio*	*Major Citing Research Category*	**(%)**
14	The measurement of observer agreement for categorical data	52694	11248	n/a	n/a	Biomedical and Clinical Sciences	(42.83)
15	Electric Field Effect in Atomically Thin Carbon Films	52380	10391	354.89	10275.93	Physical Sciences	(37.32)
16	Fitting Linear Mixed-Effects Models Using lme4	49937	24650	n/a	20059.53	Biological Sciences	(33.76)
17	The neighbor-joining method: A new method for reconstructing phylogenetic trees	49127	5353	1198.42	n/a	Biological Sciences	(72.83)
18	Self-Consistent Equations Including Exchange and Correlation Effects	49028	7542	n/a	n/a	Chemical Sciences	(40.45)
19	Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement	48847	21356	1530.22	n/a	Biomedical and Clinical Sciences	(48.19)
20	Electrophoretic transfer of proteins from polyacrylamide gels to nitrocellulose sheets: Procedure and some applications.	47930	636	n/a	n/a	Biological Sciences	(51.47)
21	Hallmarks of Cancer: The Next Generation	47379	13851	1277.49	6716.97	Biomedical and Clinical Sciences	(58.99)
22	Moderated estimation of fold change and dispersion for RNA-seq data with DESeq2	46922	27140	1327.41	4143.54	Biological Sciences	(54.54)
23	U-Net: Convolutional Networks for Biomedical Image Segmentation	44563	29289	n/a	11292.52	Information and Computing Sciences	(50.31)
24	Measuring inconsistency in meta-analyses	44494	11702	1088.77	n/a	Biomedical and Clinical Sciences	(64.18)
25	The Sequence Alignment/Map format and SAMtools	41988	15814	820.73	3194.64	Biological Sciences	(68.00

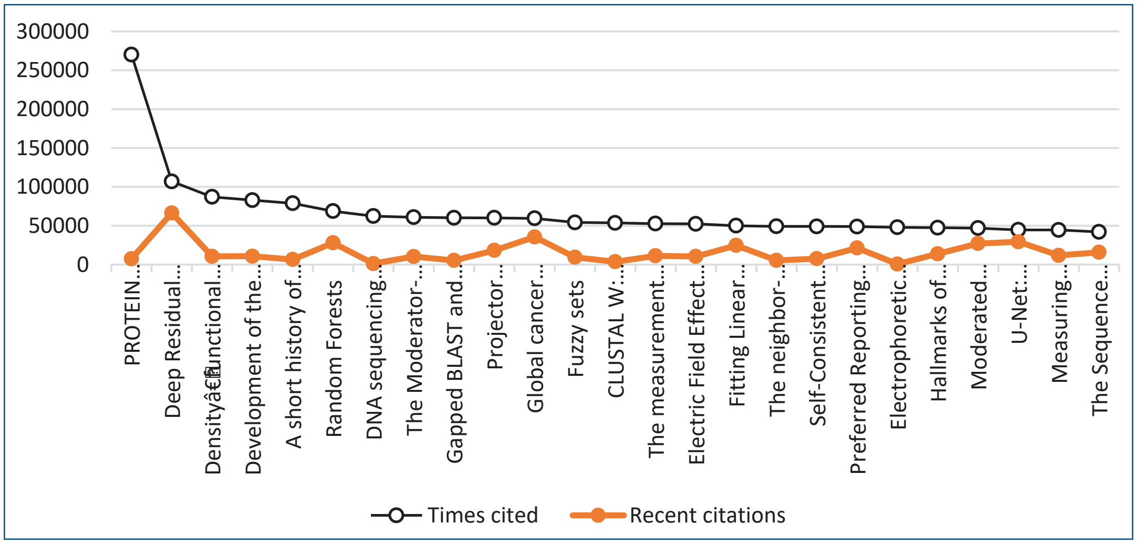


Fig. 6: Citations by Publication

Status of Open Access Publications Based on Alternative Metrics

In Table 8 and Fig. 7, the status of usage, captures, mentions, social media and citations of OA publications and also ranking of publications based on all altmetrics indicators are presented.

Usage: In this matric, "Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement" is ranked first. This publication includes 19,318 usages (32.68%). "The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic and Statistical Considerations" and "Electric Field Effect in Atomically Thin Carbon Films" with 18,427 (31.17%) and 14,788 (25.02%) are ranked second and third, respectively.

Captures: In captures, "Hallmarks of Cancer: The Next Generation," "Deep Residual Learning for Image Recognition," and "Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries" with 1,11,665 (24.50%), 40,771 (8.95%) and 38,116 (8.36%) captures are ranked first, second and third, respectively.

Mentions: The results of mentions indicator show that the most mentions (33.51%) belong to "Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries." "Hallmarks of Cancer: The Next Generation" and "U-Net: Convolutional Networks for Biomedical Image Segmentation" with 234 (15.56%) and 80 (5.32%) mentions are ranked second and third, respectively.

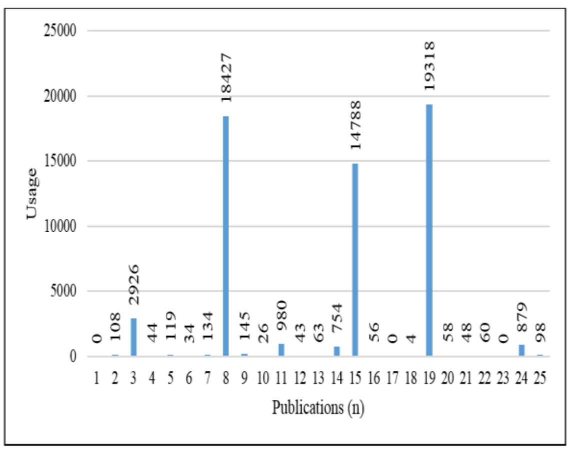
Social Media: Based on the metric data, "Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement" with the most presence (19,290 times-85.96%) and "Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries" with 1,491 times (6.64%) in social media are ranked first and second, respectively. The publication "Hallmarks of Cancer: The Next Generation" with 726 times (3.24%) is ranked third.

Citations: In citation metric, "Protein Measurement with the Folin Phenol Reagent" is ranked first. This publication includes 265,169 citations (16.18%). "Deep Residual Learning for Image Recognition" and "Density-functional thermochemistry. III. The role of exact exchange" with 104,586 (6.38%) and 90,734 (5.54%) are ranked second and third respectively. Comparing the rank of OA publications in terms of alternative metrics indicates that the publication "Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement" has the first rank in Usage and Social Media metrics. The publication "Hallmarks of Cancer: The Next Generation" has the first, second and third rank in Captures, Mentions and Social Media metrics. The publication "Protein Measurement with the Folin Phenol Reagent" has the first Citation rank.

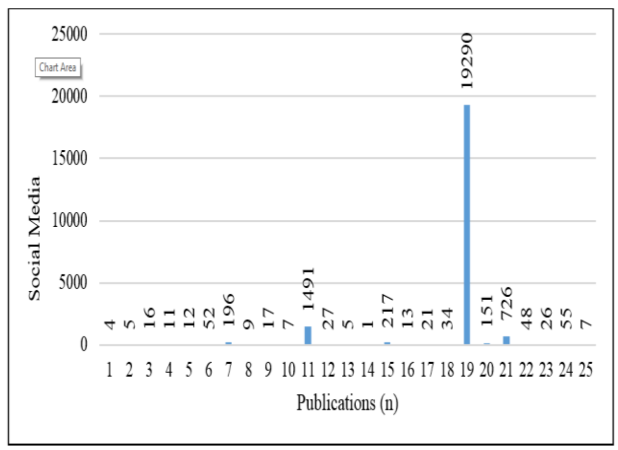
Table 8: Ranking of Highly Cited Open Access Publications by Altmetrics Indicators

Sr. No.	*Title 08/06/23*	*PlumX Metrics*				
		Usage (Rank)	*Captures (Rank)*	*Mentions (Rank)*	*Social Media (Rank)*	*Citations (Rank)*
1	Protein Measurement with the Folin Phenol Reagent	n/a	621 (24)	14 (21)	4 (24)	265169 (1)
2	Deep Residual Learning for Image Recognition	108 (11)	40771 (2)	27 (13)	5 (22)	104586 (2)
3	Density-functional thermochemistry. III. The role of exact exchange	2926 (4)	11793 (13)	16 (18)	16 (15)	90734 (3)
4	Development of the Colle-Salvetti correlation-energy formula into a functional of the electron density	44 (18)	11598 (14)	19 (17)	11 (18)	87928 (4)
5	A short history of SHELX	119 (10)	5082 (22)	10 (24)	12 (17)	81161 (5)
6	Random Forests	34 (20)	23782 (5)	49 (8)	52 (8)	69427 (6)
7	DNA sequencing with chain-terminating inhibitors	134 (9)	8210 (17)	54 (7)	196 (5)	52912 (14)
8	The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations	18427 (2)	7777 (20)	15 (19)	9 (19)	55847 (11)
9	Gapped BLAST and PSI-BLAST: A new generation of protein database search programs	145 (8)	13806 (11)	36 (12)	17 (14)	61048 (8)
10	Projector augmented-wave method	26 (21)	8361 (16)	11 (23)	7 (20)	58941 (9)
11	Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries	980 (5)	38116 (3)	504 (1)	1491 (2)	54279 (12)
12	Fuzzy sets	43 (19)	5571 (21)	22 (15)	27 (11)	62986 (7)
13	CLUSTAL W: Improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice	63 (13)	8102 (18)	23 (14)	5 (23)	56140 (10)
14	The measurement of observer agreement for categorical data	754 (7)	14503 (10)	13 (22)	1 (25)	52902 (15)
15	Electric Field Effect in Atomically Thin Carbon Films	14788 (3)	21115 (7)	72 (5)	217 (4)	53639 (13)
16	Fitting Linear Mixed-Effects Models Using lme4	56 (16)	6 (25)	45 (9)	13 (16)	41639 (22)
17	The neighbor-joining method: A new method for reconstructing phylogenetic trees	n/a	10272 (15)	9 (25)	21 (13)	51073 (16)
18	Self-Consistent Equations Including Exchange and Correlation Effects	4 (22)	17370 (9)	36 (11)	34 (10)	48705 (17)
19	Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement	19318 (1)	29692 (4)	37 (10)	19290 (1)	45800 (18)

Sr. No.	Title 08/06/23	PlumX Metrics				
		Usage (Rank)	Captures (Rank)	Mentions (Rank)	Social Media (Rank)	Citations (Rank)
20	Electrophoretic transfer of proteins from polyacrylamide gels to nitrocellulose sheets: Procedure and some applications	58 (15)	4095 (23)	22 (16)	151 (6)	44987 (19)
21	Hallmarks of Cancer: The Next Generation	48 (17)	111665 (1)	234 (2)	726 (3)	44779 (20)
22	Moderated estimation of fold change and dispersion for RNA-seq data with DESeq2	60 (14)	23744 (6)	73 (4)	48 (9)	35695 (25)
23	U-Net: Convolutional Networks for Bio-medical Image Segmentation	n/a	12404 (12)	80 (3)	26 (12)	36730 (24)
24	Measuring inconsistency in meta-analyses	879 (6)	7953 (19)	15 (20)	55 (7)	43399 (21)
25	The Sequence Alignment/Map format and SAMtools	98 (12)	19360 (8)	68 (6)	7 (21)	38353 (23)



(A)



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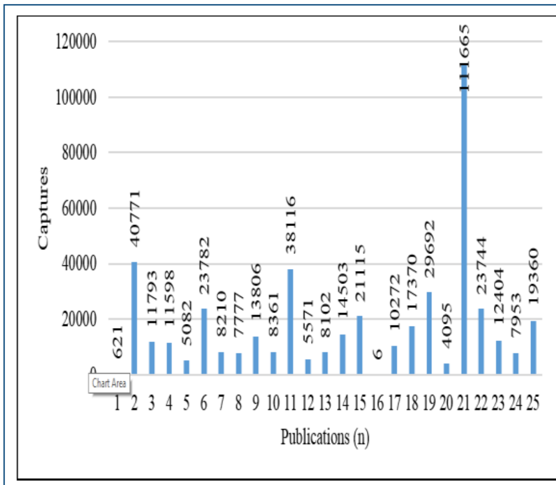
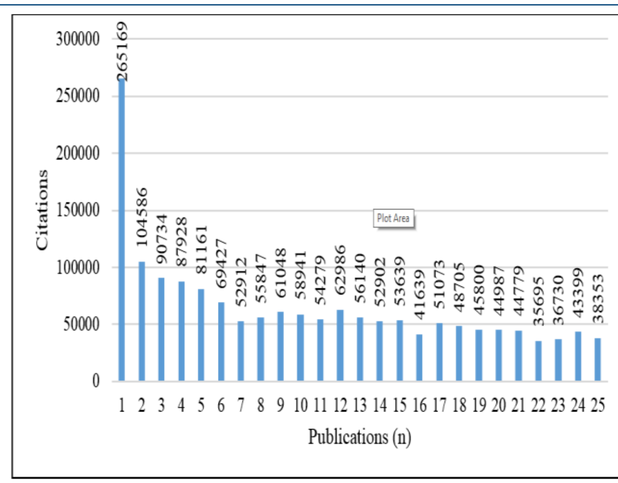
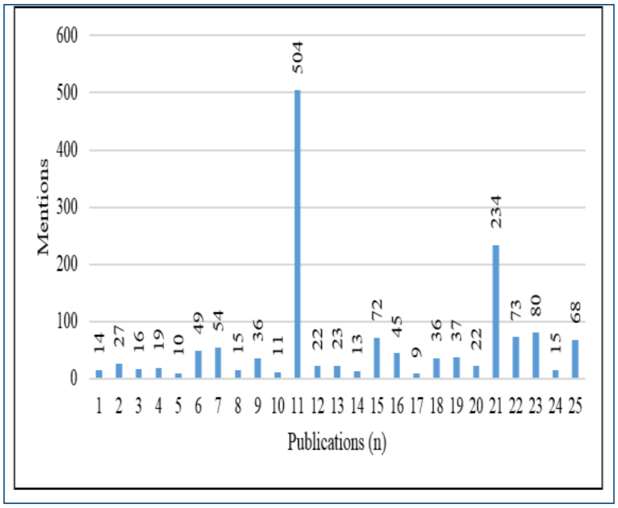


(B)



(E)



(C)

Fig. 7: Status of Open Access Publications Based on Altmetrics Indicators

To assess the normality of the data, the One-Sample Shapiro-Wilk test was conducted. The test results revealed that the data did not follow a normal distribution. Consequently, the Spearman non-parametric test was employed to analyse the correlation between Alternative Metrics and Citations in Scopus.

Correlation between Alternative Metrics and Citations in Scopus

To examine the correlation between alternative metrics and citations in Scopus, the alternative metrics were categorised into seven distinct categories: views count, usage, captures, mentions, social media, citations and AAS.

- *Correlation between Views Count and Citations in Scopus*

  The Views Count represents the combined number of abstract views and clicks on the full-text link found on the publisher's website. Analysis using Spearman's statistical test, as shown in Table 9, reveals a statistically significant positive correlation between the views count metric and Scopus citations (Spearman's $\rho = 0.413$, p-value = 0.040). Put simply, publications with higher views counts tend to attract more citations.

- *Correlation between Usage Metric and Citations in Scopus*

  According to the results of the Spearman statistical test presented in Table 9, there was no statistically significant positive correlation observed between the usage metric and Scopus citations (Spearman's $\rho = 0.011$, p-value = 0.959). This implies that publications with higher usage, including abstract views, full text views, views, clicks, downloads, library holdings, link outs, collaborators and video or audio plays, did not receive a greater number of citations.

- *Correlation between Captures Metric and Citations in Scopus*

  According to the data from Table 9, the Spearman statistical Test indicates that there is no statistically significant positive correlation between the captures metric (including bookmarks, favourites, followers, forks, readers, exports, subscribers and watchers) and Scopus citations (Spearman's $\rho = 0.155$, p-value = 0.458). In simpler terms, having more captures does not have a significant impact on increasing the number of citations for publications.

- *Correlation between Mentions Metric and Citations in Scopus*

  Based on the data presented in Table 9 and the results of the Spearman statistical test, it is evident that there is a statistically significant positive correlation between the mentions metric (including blog posts, comments, forum topic count, gist count, news mentions, Q&A site mentions, references and reviews) and Scopus citations (Spearman's $\rho = 0.449$, p-value = 0.024). This indicates that these mentions metrics have a significant impact on increasing the number of citations for publications.

- *Correlation between Social Media Metric and Citations in Scopus*

  Based on the data presented in Table 9, a statistically significant positive correlation was observed between the social media metric and Scopus citations (Spearman's $\rho = 0.399$, p-value = 0.048). This implies that the use of social media metrics such as tweets, shares, likes, comments, ratings, recommendations and scores can contribute to an increase in the number of citations for papers.

- *Correlation between Citations Metric and Citations in Scopus*

  Based on the data analysed in Table 9 using the Spearman statistical test, it is evident that there is a highly significant positive correlation between the citations metric and Scopus citations (Spearman's ρ = 0.996, p-value = 0.000). This indicates that an increase in paper citations in Scopus is strongly associated with gaining citations in Plum Analytics.

- *Correlation between Altmetric Attention Score (AAS) and Citations in Scopus*

  The results obtained from Spearman correlation analysis, as presented in Table 9, indicate an insignificant positive correlation between the AAS and citations in Scopus (Spearman's ρ = 0.289, p-value = 0.161). This suggests that the online attention a publication receives, as measured by the AAS, does not have a substantial impact on the number of citations it receives.

Table 9: Correlation between Alternative Metrics and Citations in Scopus

Alternative Metric	*Citations in Scopus*	
	Spearman's Correlation Coefficient	*P-Value*
Views Count Matric	0.413	0.040
Usage Metric	0.011	0.959
Captures Metric	0.155	0.458
Mentions Metric	0.449	0.024
Social Media Metric	0.399	0.048
Citations Metric	0.996	0.000
Altmetric Attention Score	0.289	0.161

Conclusion, Limitations and Future Research

The study aimed to analyse the altmetric performance of highly cited OA publications using data from the Dimensions and Scopus databases. A search was conducted on 7th June, 2023, yielding over 44 million publications. From this pool, 25 highly cited publications were selected for analysis. Data on views count, usage, captures, mentions, social media activity and citations were gathered from the Scopus, Plum Analytics Categories database. The AAS of the publications was obtained from the Dimensions database. The descriptive statistics revealed that the 25 selected publications were authored by 83 individuals from 11 different countries and represented 45 organisations. Most of the publications were multi-authored, indicating significant collaboration. The publications cited a total of 917 external sources and received a substantial number of citations, with over 1.6 million recorded in the Dimensions database and over 1.6 million in the Scopus database.

The performance analysis showed the publication trends over time, with fluctuations in the number of publications from 1951 to 2018. Articles were the most prevalent document type among the publications, followed by conference papers and reviews. The study also identified diverse sources from various disciplines as the most prolific journals. The ranking of OA publications based on alternative metrics highlighted four highly cited publications: "Protein Measurement with the Folin Phenol Reagent," "Deep Residual Learning for Image Recognition," "Density-functional thermochemistry. III. The role of exact exchange," and "Development of the Colle-Salvetti correlation-energy formula into a functional of the electron density." These publications received over 80,000 citations each, with the first two publications being the most cited. The study examined the correlation between alternative metrics and citations in Scopus, analysing views count, usage, captures, mentions, social media activity and the AAS. Notably, publications with higher views counts tended to attract more citations. However, no significant positive correlation was observed between usage and captures metrics and citations. On the other hand, mentions and social media metrics showed a significant positive correlation with citations, indicating the influence of social media engagement on research dissemination and impact.

The current study contributes to the existing literature by exploring both citation metrics and altmetrics advantage of OA articles, offering a comprehensive perspective on research performance. Utilising a wide range of online metrics, this study provides valuable insights into the impact of OA publications and the influence of social media on research dissemination. However, it is essential to acknowledge some limitations. Firstly, the study focused on a sample of 25 highly cited publications, which may not fully represent the entire OA landscape.

Expanding the sample size and including a more diverse set of publications could provide a more comprehensive understanding of OA's impact. Additionally, altmetrics are still evolving, and their interpretation may vary across disciplines and platforms, warranting caution when drawing conclusions solely based on altmetrics data.

Future research in this area should continue to explore the citation advantage of OA articles, considering various factors such as subject area, publication type and geographic region. Investigating the long-term impact of OA publications and their influence on different academic communities would be valuable. Moreover, understanding the specific mechanisms through which social media influences research dissemination and citation rates can provide researchers and publishers with actionable insights to maximise the reach and impact of their work. Additionally, developing standardised and discipline-specific altmetrics methodologies can enhance the reliability and comparability of altmetrics data. Furthermore, investigating the relationship between altmetrics and academic reputation, funding opportunities and career advancement can shed light on the broader implications of online metrics in academia.

In conclusion, the combination of OA publishing and social media engagement represents a powerful mechanism for increasing the visibility and impact of research. As the scholarly landscape continues to evolve in the digital age, it is crucial for researchers, publishers and institutions to embrace OA and harness the potential of social media to enhance research dissemination and foster collaboration within the global academic community. By addressing the limitations and advancing future research in this area, scholars can continue to leverage emerging technologies and metrics to accelerate the progress of knowledge dissemination and scientific discovery.

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