

# Publications in gold open access and article processing charge expenditure: evidence from Indian scholarly output

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*Article processing charges (APCs) ensure the financial viability of open access (OA) scholarly journals. The present study analyses the number of gold OA articles published in the Web of Science (WoS)-indexed journals by Indian researchers during 2020, including subject categories that account for the highest APC in India. Besides, it evaluates the amount of APC expenditure incurred in India. The findings of this study reveal that Indian researchers published 26,127 gold OA articles across all subjects in WoS-indexed journals in 2020. Researchers in the field of health and medical sciences paid the highest APC, amounting to USD 7 million, followed by life and earth sciences (USD 6.9 million), multidisciplinary (USD 4.9 million), and chemistry and materials science (USD 4.8 million). The study also reveals that Indian researchers paid an estimated 17 million USD as APC in 2020. Furthermore, 81% of APCs went to commercial publishers, viz. MDPI, Springer–Nature, Elsevier and Frontier Media. As there is a growing number of OA publications from India, we suggest having a central and state-level single-window option for funding in OA journals and backing the Plan S initiative for OA publishing in India.*

**Keywords:** Article processing charges, commercial publishers, gold open access, scholarly output, subject category.

THE emergence of open access (OA) is a watershed moment in the scholarly publications landscape, as it attempts to bridge the chasm between haves and have-nots of scientific publications, thereby paving the way to reaching equity and inclusion. The OA literature is freely accessible online, so anyone with an internet connection can read, download, copy, distribute, print and search for articles, among other things<sup>1</sup>. There are two routes for making scholarly outputs openly accessible: green OA, where the researcher self-archives documents in an OA institutional or subject repository, and gold OA, where an article is published immediately as OA in an online journal<sup>2</sup>. Of late, gold OA is widely preferred in most institutions across the world due to its accessibility, quality<sup>1</sup>, efficacy, cost-effectiveness<sup>3,4</sup> and citation advantages over toll access journals<sup>5–8</sup>. However, sustaining the gold OA model requires monetary support. In the traditional publishing model, financial support is made available through journal subscriptions and purchases, but this is not possible in the case of gold OA. The economic sustainability of gold OA depends on the article process-

ing charges (APCs) that an author or his/her institution pays on the author's behalf to publish a manuscript. In the last few decades, gold OA has witnessed significant growth due to the emergence of professional OA publishers like Public Library of Science (PLoS), Frontiers and Multidisciplinary Digital Publishing Institute (MDPI), including commercial OA publishers like Springer, Elsevier and Wiley<sup>9</sup>. Commercial publishers have recently started offering gold OA options for authors to publish in their respective journals.

The APC policy has been helpful to gold OA journals to sustain themselves in the publishing market. PLoS, which started its publication journey in 2001, and more recent publishing companies like Frontiers Publishing in 2007, have been successful in the APC-based model. The number of journals levying APCs has been growing consistently; it was 1825 in 2011 (ref. 10) and 5661 in 2022 (ref. 11). The APC model has changed the underlying strategies of the journal business model, shifting from the demand-side to supply-side economics; instead of charging readers and librarians for subscription or license of scholarly work, the OA model supports the production cost of an article by the author paying the APC<sup>3</sup>. Science, technology, engineering and mathematics (STEM) journals have a higher APC than journals in social science and humanities, according to an analysis of APCs across fields<sup>12</sup>. Particularly, high APC is found in the subjects like biology, chemistry and medicine<sup>12</sup>.

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A country-level study showed that major OA publications are in STEM subject areas only; for example, Brazil and Chile published the highest number of OA articles in the health sciences and biological sciences categories<sup>13,14</sup>. Brazil spent USD 36 million on APCs during a five-year period<sup>14</sup>, whereas Chile spent an estimated whopping USD 9.1 million in a single year<sup>13</sup>. Zhang *et al.*<sup>15</sup> studied six countries (UK, France, the Netherlands, Norway, China and the USA) and their APC spending between 2015 and 2020. They found that China spent USD 1355 million in gold and hybrid journals, followed by the USA with USD 1168 million and the UK with USD 609 million in APCs. India spent USD 16.75 million towards APCs for publishing 14,297 papers between 2010 and 2014 (ref. 16). Against this backdrop, the present study analyses the number of articles published in the Web of Science (WOS) indexed journals by Indian researchers and APC expenditure incurred in India during 2020. Besides, it explores the subject category-wise APCs and APCs levied by publishers to publish in their OA journals.

## Methodology

In order to achieve the overarching objectives of the present study, the Web of Science Core Collection database was chosen to retrieve the gold OA publications from India. A search query was made using CU = India and PY = 2020, and it was limited to gold OA articles. The search query yielded 30,604 articles. We further refined and delimited to research and review articles only, which resulted in 26,127 documents (23,274 articles and 2853 review articles) published in 2336 journals that were selected for the study. The bibliographic data was extracted into a spreadsheet. We further analysed the 2336 journals based on subject category, APCs, publishers and funding. The Directory of Open Access Journals (DOAJ) was used to determine the APCs of 2336 journals. Majority of the APC data were obtained from DOAJ. The information on APCs was not available on DOAJ for a few journals, so we manually retrieved it from the respective journal websites and added it to our spreadsheet. Since USD is a commonly used international exchange currency, it was essential to uniformize and convert the APCs that various publications collected on multiple currencies, including GBP, EURO, USD, INR and JPY. The exchange rate for USD was used to convert all other currencies. WoS research areas were used for the subject category analysis. These were regrouped into nine major subject categories based on the classification made by Martin-Martin *et al.*<sup>17</sup> and updated by Krauskopf<sup>13</sup>.

## Data analysis

The findings of the present study reveal that the total number of OA publications from India has been increasing steadily over the years (Figure 1). In 2011, there were

14,850 OA publications, with 5864 being gold OA and 8986 other OA publications. By 2020, the total number of OA publications had increased to 50,662, with 30,604 being gold OA and 20,058 other OA publications. Gold OA publications have grown significantly each year, and a phenomenal increase was witnessed during 2014–15. Although Gold OA is the preferred model, hybrid and diamond OA models also help in the overall growth of OA publishing. This trend reflects a growing recognition of OA publishing in facilitating greater equitable access to knowledge.

## *OA publications by Indian researchers in WoS-indexed journals*

The findings of this study also reveal that Indian researchers across all subjects have published 26,127 gold OA articles in WoS-indexed journals in 2020. Among these, 18,150 articles were published in 1517 journals with APCs, whereas 7977 were published in 819 journals without APCs.

A cross-comparison of journals with and without APCs showed that the highest number of journals was from health and medical sciences subjects. About 33.77% and 18.77% of health and medical sciences and life and earth sciences articles were published in 659 and 438 journals with APCs respectively. Similarly, 52.60% and 12.94% of health and medical sciences, and physics and mathematics articles were published in 315 and 100 journals without APCs respectively. A small percentage of articles from social science, humanities, literature and arts, and business, economics and management were published in journals with and without APCs (Table 1).

## *APCs expenditure incurred by Indian researchers*

While analysing APCs by subject categories, it is found that health and medical sciences researchers paid USD 7 million as APCs followed by life and earth sciences (USD 6.9 million), multidisciplinary (USD 4.9 million), and chemistry and materials science (USD 4.8 million). Humanities, literature and arts, social sciences, business, economics and management categories accounted for only USD 53,000, 311,000 and 117,000 respectively. The APC charges varied significantly among subject categories, reflecting the cost of publishing in various fields (Table 2).

The APC calculations showed that around USD 30 million was cumulatively spent on APC fees in 2020. It is difficult to assume how much Indian researchers bear when there is a multi-country collaborative paper. Extant literature suggests that the corresponding author most likely pays the APCs<sup>18–20</sup>. Following the corresponding author criterion, APC expenditure incurred by Indian researchers was estimated. We found 21,268 out of 26,127 articles, with corresponding authors from India, were published in 2029 unique journals. Among these journals, 1267 charged for publishing. Plausibly, an estimated USD 17 million

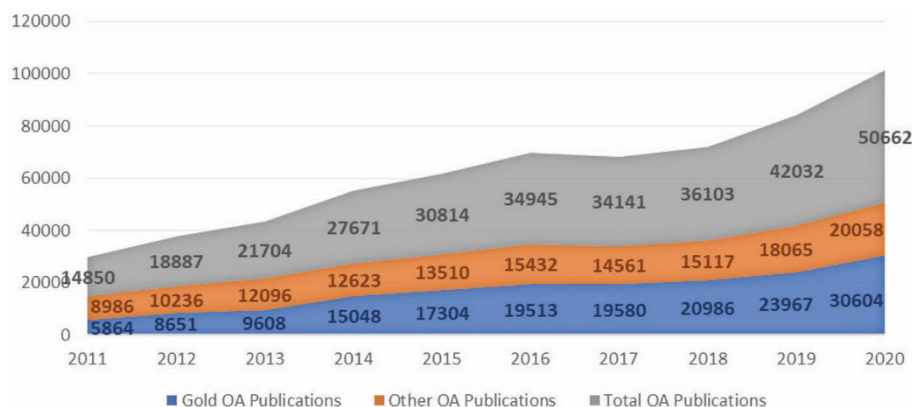


Figure 1. Growth of open access (OA) publications.

Table 1. Subject category-wise open access (OA) publications with and without article processing charges (APCs)

Subject category	OA journals with APCs			OA journals without APCs		
	NJ	NP*	Percentage of NP	NJ	NP*	Percentage of NP
Health and medical sciences	659	7,059	33.77	315	4,457	52.60
Life and earth sciences	438	3,923	18.77	151	1,061	12.52
Chemistry and materials sciences	161	3,246	15.53	69	494	5.83
Multidisciplinary	70	2,620	12.53	20	183	2.16
Engineering and computer science	180	1,890	9.04	125	876	10.34
Physics and mathematics	135	1,605	7.68	100	1,096	12.94
Social science	38	256	1.22	50	99	1.17
Humanities, literature and arts	17	200	0.96	9	14	0.17
Business, economics and management	24	105	0.50	47	193	2.28

\*The number of publications will not be the same as a journal may fall under multiple categories.  
 NJ, No. of journals; NP, No. of publications.

Table 2. APCs by subject category

Subject category	NP*	Journal levied APC	Minimum (USD)	Maximum (USD)	Total (USD)
Business, economics and management	298	105	315	3,060	116,542
Chemistry and materials sciences	3,740	3,246	8	5,200	4,821,047
Engineering and computer sciences	2,758	1,882	50	5,200	2,961,936
Health and medical sciences	11,516	7,059	20	6,000	7,181,307
Humanities, literature and arts	214	200	77	1,818	53,281
Life and earth sciences	4,984	3,923	35	5,200	6,969,703
Multidisciplinary	2,803	2,620	93	5,000	4,993,532
Physics and mathematics	2,701	1,605	23	5,200	2,606,079
Social science	355	256	20	2,178	310,865

\*Both with and without APC documents.

(USD 17,086,222) was paid by Indian researchers as APCs to publish 14,003 articles in gold OA journals.

### Research area-wise APCs

APC per document varied from journal to journal; the minimum APC was USD 8 for chemistry and materials sciences, and the maximum was USD 6000 for health and medical sciences journals (Figure 2). In the area of business, economics and management, the highest APC was between USD 1001 and 1500, while the second highest was bet-

ween USD 251 and 500, followed by the range USD 501–1000 and USD 1501–2000. No APC was found above USD 3500 and in the USD 1–250 range. In chemistry and materials science, APC was between USD 500 and 2500 for most documents. There were 1140 documents in the USD 1001–1500 price band, 838 in USD 2001–2500, and 543 articles in the USD 501–1000 band. In the case of engineering and computer science, the highest number of documents was in the APC band of USD 1501–2000. The second highest was in USD 2001–2500, with 458 papers charged APC, followed by 350 articles in the price band USD 1001–1500 and 206 in USD 501–1000.

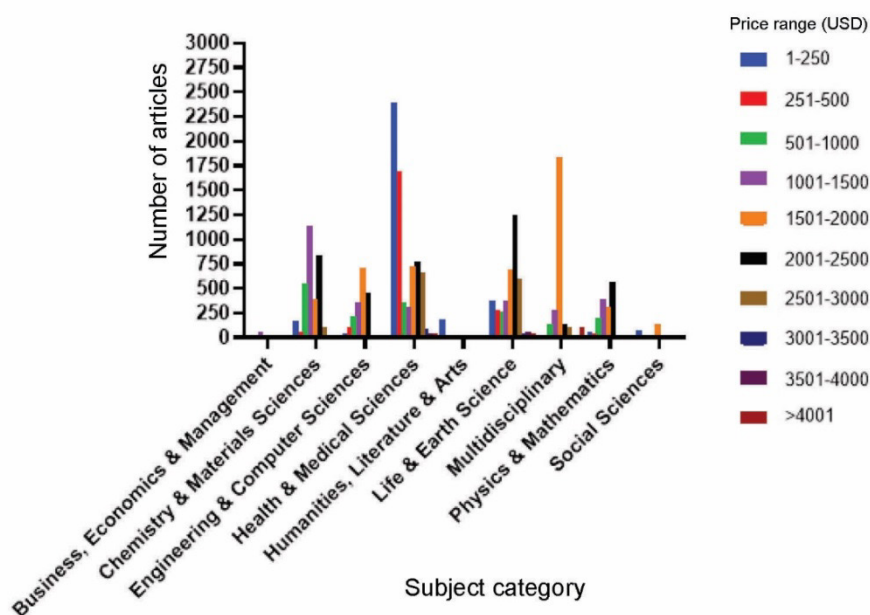


Figure 2. Research area-wise APCs.

Table 3. APCs levied by the publishers

Publisher	NJ	NP	APCs levied (USD)	Percentage
Commercial publishers	1,193	13,924	20,330,120	81.42
Non-university academic publishers	224	3,858	4,268,737	17.10
University press	100	368	369,206	1.48

The health and medical sciences category was different from the others, where a significant number of documents (2385 articles) were in the lowest price band, i.e. USD 1–250. Similarly, there were 1692 articles in the USD 251–500 range, 775 documents in USD 2001–2500, and 725 articles in USD 1501–2000. The results also show that 167 articles were in the highest APC range category (USD 3000 and above). Most humanities, literature and arts articles were in the USD 1–250 price range. There were 26 documents in the APC band of USD 251–2000, and no documents were found in the range of USD 2000 and above. Humanities, literature and arts journals had the lowest APC compared to other research areas. In the case of life and earth sciences, the highest number of documents (1239) was in the APC range of USD 2001–2500. There were 685 documents in the USD 1501–2000 range, followed by 586 documents in the USD 2501–3000 range. Many articles were in the lower APC bands in life and earth sciences. Also, 125 articles charged more than USD 3000 as APC. In physics and mathematics, most articles fell in the USD 500–2500 range. The highest number of documents (567) was in the USD 2000–2500 range, followed by 389 papers in USD 1001–1500 and 315 in the USD 1501–2000 range. Eleven papers fell in the high APC range above USD 3000. In social science, many documents (130) were in the USD 1501–2000

range, followed by 66 documents in USD 1–250. There were no documents in the higher range of APC (above USD 2500). Around 70% (1837) of documents in the multidisciplinary category were in the USD 1501–2000 range and 272 in USD 1001–1500. This was the only category where over 100 documents were found in the highest APC category of USD 4000 and above.

APCs in OA journals: Publisher fees analysis

Publishers are classified into three categories based on their business and role: commercial publishers (e.g. Elsevier, Wiley, Springer), non-university academic publishers (affiliated to societies or organizations) and university press (e.g. Oxford University Press). The study results showed that 81.42%, 17.1% and 1.48% of APCs were received by commercial publishers, non-university academic publishers and university press respectively (Table 3). Only 5% of the total APCs went to Indian publishers during the study period.

MDPI was the top publisher where Indian researchers published their articles. It published around 2360 articles in its 143 flagship journals. The total APC of these 2360 articles was USD 4,597,438 (Table 4).

**Table 4.** Top 20 publishers by APCs in 2021

Publisher	NJ	NP	Total APCs (USD)	Percentage
MDPI	143	2,360	4,597,438	18.42
Springer–Nature	48	1,380	3,197,921	12.81
Elsevier	133	1,871	2,857,064	11.45
Frontiers Media S.A.	53	937	2,616,330	10.48
BMC	142	609	1,318,241	5.28
IEEE	8	567	974,920	3.91
Public Library of Science (PLoS)	7	479	935,359	3.75
Wiley	76	368	865,096	3.47
The Royal Society of Chemistry	4	575	638,975	2.56
Hindawi Limited	95	334	573,425	2.30
American Chemical Society	2	444	554,750	2.22
IOP Publishing	10	372	552,986	2.22
Wolters Kluwer	26	1,454	513,411	2.06
Taylor & Francis	76	330	442,281	1.77
BMJ Publishing Group	13	138	342,761	1.37
Dove Medical Press	39	150	316,806	1.27
American Physical Society	3	104	265,500	1.06
SAGE Publishing	59	177	262,212	1.05
Oxford University Press	23	129	216,287	0.87
JCDR Research and Publications Private Limited	1	741	203,775	0.82

Springer–Nature and Elsevier published 1380 and 1871 articles with APC of USD 3,197,921 and 2,857,064 respectively. Besides commercial publishers, many society publishers like the Royal Society of Chemistry, the American Chemical Society, the American Physical Society, and the Institute of Physics also published gold OA articles in their journals.

## Discussion and conclusion

The objective of OA publishing is to make the research accessible to everyone. In spite of the constant growth in OA publications<sup>21</sup>, there is a barrier to publishing in quality OA journals, especially gold and hybrid OA, which levy APCs for publications. APC has become ubiquitous in the Global North, adopted by many for-profit organizations and encouraged by many funding organizations in the US and UK to publish in APC-levied journals<sup>22</sup>. In 2010, the number of articles published in APC-funded OA journals indexed in Scopus surpassed that published in OA journals funded by other means. Further, the APC-funded revenue model has increased the share of OA articles from 10% in 2003 to 50% in 2013 (ref. 23). However, the high APCs have been an issue for low-income and underdeveloped countries<sup>24</sup>. In the Global South, APC is a real obstacle to publishing in high-quality OA journals<sup>25–27</sup>. The present study reveals that Indian researchers published 26,127 gold OA articles across all subjects in WoS-indexed journals in 2020. Among these, 18,150 were published in 1517 journals with APCs, whereas 7977 papers were published in 819 journals without APCs. In line with earlier studies<sup>13,14,28,29</sup>, the maximum number of articles was published in health and medical science (33.77%), followed by life and earth sciences (18.77%), and chemistry and

materials science (15.53%). Fewer articles were published in gold OA from humanities, literature and arts, followed by business, economics and management, and social science subject areas. Indian researchers paid USD 17 million as APCs in 2020. Researchers in the field of health and medical sciences paid the highest APCs, adding up to USD 7 million, followed by those in the areas of life and earth sciences (USD 6.9 million), multidisciplinary (USD 4.9 million), and chemistry and materials science (USD 4.8 million). Humanities, literature and arts, social science, and business, economics and management accounted for only USD 53,000, 311,000 and 117,000 respectively. The result shows that 93% of multidisciplinary journals levied APCs similar to humanities, literature and arts, followed by chemistry and materials science journals (86%) compared to other subject areas. The multidisciplinary area had 70% of publications in the 1500–2000 APC range and the highest number in the above USD 4000 range. The health and medical sciences, and life and earth sciences subject areas had the highest publications in the lowest (USD 1–250) and highest APC range (above USD 4000).

Extant literature reveals a constant increase in APCs by most publishers like BioMed Central, Frontiers Media, MDPI and Hindawi<sup>30,31</sup>. The publisher-wise analysis showed that 81% of APCs went to commercial publishers, viz. MDPI, Springer–Nature, Elsevier and Frontier Media. The present study reveals that around 5% of APCs go to Indian publishers. One of the objectives of OA was equitable access and to check the rampant commercialization of scholarly publications. Still, surprisingly, many established publishers have positioned themselves in the OA landscape. The list of top publishers shows that MDPI gains 18% of all APCs, followed by Springer–Nature, Elsevier and Frontier Media. There is one Indian publisher in the top-20 list of publishers.

Wolter Kluwer published many OA journals from India after acquiring Medknow publisher from India. The publisher-wise price range analysis showed that the highest APC was from Springer-Nature and the lowest was from Wolter Kluwer.

The primary issue for Indian researchers is that there is no dedicated system for funding OA publications and no nationwide OA mandate like in many other countries. However, there are funder-level OA mandates like the Council of Scientific and Industrial Research, Indian Council of Agricultural Research, Department of Biotechnology and Department of Science and Technology, and organizational-level OA mandates like the National Institute of Technology-Rourkela and Mahatma Gandhi University, Kottayam. These OA policies are old and discuss mostly adding a copy of the published article into the repository and not publishing in OA journals. Hence, formulation of national-level OA policies in India is the need of the hour since OA is inevitable for equity and access to scholarly communications. India must consider a country-level OA policy mandate that helps researchers publish their funded research in OA journals. With a large pool of researchers in India, initiatives may be taken to have 'one nation, one OA repository' of all the preprint publications and back the Plan S initiative, which mandates OA publication for research supported by public agencies. Besides, it should provide infrastructural support for new and existing OA journals in India, thereby contributing enormously to making scholarly publications accessible without any paywall.

*Conflict of interest:* The authors declare that there is no conflict of interest.

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