


REVIEW

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The evolving landscape of publishing in human reproduction: an analysis of scientometric data, open-access publishing, and article processing charges

Hakki Uzun^{1*} , Gökem Akça¹, Berat Sönmez¹, Erdem Orman¹, Yakup Kaçan¹ and Eyüp Dil¹

Abstract

Background This bibliometric study aims to examine the associations of journals in the field of human reproduction with their access types and article processing charges to evaluate the evolving landscape of publishing in human reproduction.

Methods The primary databases, including Clarivate Analytics Master Journal List, Scopus[®], PubMed, and Directory of Open Access Journals, were scrutinized to identify pertinent journals within the realm of human reproduction, utilizing keywords such as reproductive, reproduction, fertility, and infertility. Journals were excluded if they were not actively publishing in English or primarily focused on reproductive health, men's health, sexual medicine, embryogenesis, developmental biology, or veterinary medicine concerning animal reproduction. A thorough characterization of the journals was conducted, followed by a comparative analysis of citation metrics and article processing charges across various access models.

Results Forty-one journals were included into the study. A significant increase in the proportion of gold and diamond open-access journals was observed, rising from 42% (13 out of 31) to 53.6% (22 out of 41) by 2023. Hybrid journals demonstrated superior citation metrics compared to diamond open-access journals. For hybrid journals, a statistically significant, moderately positive correlation was found between article processing charges and CiteScore ($r_s(27) = 0.515, p < .024$). Conversely, no correlation was observed between article processing charges and CiteScore for gold open-access journals ($r_s(27) = 0.445, p = 0.147$). The mean article processing charges for all hybrid and gold open-access journals were calculated as US \$3032.88 ± 1108.514 (312 to 4430). Specifically, the mean article processing charges for hybrid journals (US \$3617.4 ± 610.19) were significantly higher than those for gold open-access journals (US \$1916.82 ± 988.32), with a difference of 1700.658 (95% CI: 1124.861–2276.455), $t(30) = 6.032$, and $p < .0005$.

Conclusion Hybrid journals in the field of human reproduction carry fees nearly twice as high as those of gold open-access journals. The charging policies of gold open-access journals, which are not contingent upon citation metrics, emphasize the importance of caution for both authors and funders.

Keywords Metrics, Open access, Cost, Article processing charge

*Correspondence:

Hakki Uzun
hakuzun@yahoo.com

¹ Department of Urology, Recep Tayyip Erdogan University School of Medicine, Rize, Turkey

Background

The conventional subscription access model has served as the cornerstone of medical publishing for centuries [1]. However, a significant shift has occurred within scientific publishing towards an open-access (OA) model, where

article processing charges (APCs) are paid or access is free of charge. This shift has coincided with a steady annual increase in the global publication output, characterized by the emergence of numerous new journals requiring APC payments [2]. Publishers have responded by converting their traditional subscription access journals to either hybrid or fully open-access models, thereby boosting their revenues. It is noteworthy, however, that this transition has primarily been motivated by financial incentives rather than a genuine commitment to OA principles [3]. Consequently, researchers now face a new payment structure for disseminating their work, placing them under significant financial strain and resulting in reduced earnings for those without external funding.

The prevalence of OA publications has steadily risen, reaching 24% by 2018 [4]. Authors are increasingly drawn to OA platforms due to the pressures to publish, challenges inherent in subscription access publishing, and the appeal of rapid dissemination and free accessibility [5]. Furthermore, research institutions and funders are advocating for OA publishing, and universities and libraries are favoring the open-access model to counteract the upward trend in subscription costs [6]. However, there are reservations that reliance on APCs in OA publishing could disrupt the traditional meritocratic nature of medical publishing [7, 8]. Nevertheless, the primary advantage of OA publishing lies in its provision of free access to articles, which facilitates the dissemination of scientific information — a fundamental principle of scientific inquiry [9].

The absence of comprehensive listings for human reproductive journals poses a significant challenge for authors seeking to submit their articles. Yet, the prevalence of similar journal names poses a risk of confusion regarding access types and associated APCs for researchers. Conducting an analysis can elucidate the present landscape of human reproduction publishing, offering insight into the ethical considerations and correlations between access models and APCs within these journals. Such an examination can serve to guide authors in making informed decisions when submitting their work.

Methods

This study conducts a cross-sectional bibliometric analysis of journals pertaining to human reproduction. Inclusion criteria mandated English-language publications from peer-reviewed journals predominantly dedicated to human reproduction, published by active publishers as of December 2023. Additionally, for a journal to be eligible for inclusion in the study, it needed to be indexed in at least one of the four specified databases. Pseudo-journals exhibiting predatory publishing practices were excluded from consideration.

A comprehensive search was conducted across various databases, including the National Library of Medicine Catalogue/PubMed, Scopus® (Elsevier BV, Amsterdam, Noord Holland, The Netherlands), Clarivate Analytics Master Journal List directory, and Directory of Open Access Journals (DOAJ), utilizing keywords such as reproduction, reproductive, fertility, and infertility. Journals deemed pertinent to the field of human reproduction and meeting the predetermined criteria following a meticulous assessment were incorporated into the study.

Journals were ineligible for inclusion in this study if they were not actively publishing, were published under their previous titles, were not published in English, or primarily focused on reproductive health, sexual medicine, men's health, embryogenesis, developmental biology, or veterinary medicine concerning animal reproduction. However, it is noted that certain journals in related fields, such as animal reproduction, biology, sexual medicine, and reproductive health, may occasionally contain articles relevant to human reproduction. In cases where the number of such articles was minimal, these journals were not considered for inclusion. Furthermore, journals publishing fewer than 10 articles annually, and supplements, were also excluded from the analysis.

Access type

Journals were systematically searched on their respective websites to ascertain their access types and were categorized into four groups: subscription access, hybrid, gold OA, and diamond OA.

APCs are fees imposed by journals on authors or funders for the publication of original research, case studies, reviews, or brief articles. Subscription access represents the traditional publishing model wherein journals restrict access to articles behind a paywall, without charging authors for submission or publication. Hybrid type describes a model where authors or funders have the option to pay an APC to make their article openly accessible within a subscription access journal, effectively enabling hybrid journals to publish both subscription access and OA articles. Gold OA journals require authors to pay an APC, granting unrestricted online access to the journal's entire content. Diamond OA encompasses journals freely accessible on the journal's website and in repositories, akin to gold OA journals. However, authors are not mandated to pay for article publication, and journals do not derive revenue from this model. The operational expenses of diamond OA journals are typically covered by institutional affiliations.

Citations metrics

Journal Impact Factor (JIF) and CiteScore are commonly utilized citation metrics assessing the average

number of citations per paper. Journal Citation Index (JCI) quantifies the relative citation impact of a particular paper by comparing its citations to a global baseline, offering a readily interpretable measure that facilitates comparison across closely aligned fields, such as the biological sciences. Source Normalized Impact per Paper (SNIP) evaluates the impact of individual citations, assigning greater significance in fields with lower citation frequencies to standardize comparisons across disciplines. SCImago Journal Rank (SJR) calculates the average weighted citations of publications indexed in Scopus, accounting for the citation rates of the journals themselves. Additionally, SJR provides quartile rankings (Q1–Q4) for journals based on their citation performance.

JIF and JCI scores were retrieved from the Journal Citation Reports for the year 2023. The investigation encompassed the assessment of CiteScore, SNIP, SJR, h-index, and quartiles of journals utilizing the Scopus database and the associated SCImago Journal and Country Rank portal.

Study design

Journals were systematically examined based on their titles and tables of contents to ascertain their relevance to the field of human reproduction. Information regarding access type, APCs, publication of original and/or review articles, date of first issue, publication frequency, journal affiliation, and publisher was collected through a thorough review of each journal's website. A few journals have multiple affiliations; however, only one was documented. APCs were documented in US dollars (US\$).

In this study, a characterization of publications in the field of human reproduction was conducted, followed by a comparative analysis of citation metrics and APCs across access types.

Statistical analyses

A Kruskal–Wallis test was employed to assess differences in citation metrics among study cohorts (hybrid, gold OA, diamond OA), given their non-normal distribution. Independent *t*-tests were conducted to compare the APCs of the hybrid and gold OA groups, with significance determined at $p < 0.05$. Spearman's ranked correlation test was utilized to explore the relationship between CiteScore and APCs. Additionally, Spearman correlation coefficients were employed to investigate associations between citation metrics, specifically JIF and CiteScore and SNIP and CiteScore. SPSS (version 23; IBM, Armonk, NY, USA) was used for the calculations.

Results

Journal characterization

From the four databases—Master Journal List, Scopus, PubMed/MEDLINE, and DOAJ—a total of 157 journals were identified. However, only 41 were determined to be peer-reviewed journals focusing on human reproduction. Specifically, 35 journals were indexed in WOS, 40 in Scopus, and 37 in PubMed. Interestingly, only one journal was exclusively indexed in DOAJ, while 17 journals were indexed in both DOAJ and other databases.

Remarkably, 51.2% (21 out of 41) of journals in the field of human reproduction are affiliated with the five major publishing houses, including Elsevier (10 out of 41), Wiley-Blackwell (4 out of 41), Springer Nature (4 out of 41), Sage (none), and Taylor and Francis (3 out of 41). This percentage was slightly lower at 44.4% (16 out of 36) prior to 2013. Notably, none of the diamond OA journals were published by these major publishers. Furthermore, Oxford University Press and Wolters Kluwer Health publish four and two journals, respectively. Of the 41 journals analyzed, 37 (90.2%) maintain affiliations with associations, societies, or universities. Eight of the 41 journals are published monthly, 6 are bimonthly, and 15 are quarterly. Merely three journals (*F and S Reviews*, *Human Reproduction Update*, *Seminars in Reproductive Medicine*) exclusively consider review articles. Additionally, seven journals (17%) have been identified as sister publications. Furthermore, one journal is dedicated to reproductive toxicology, while two others are focused on reproductive immunology. In terms of SCImago Q categorization, 9 journals were designated as Q1, 17 as Q2, 10 as Q3, and 1 as Q4.

Longitudinal publication trends

The journals and their corresponding access types are outlined in Table 1. Of the total, 19 were categorized as hybrid, 13 as gold OA, and 9 as diamond OA. Notably, no subscription access journal was identified. Furthermore, 25 out of 41 journals had previously operated as subscription access journals. Among these, 16 journals (16/25) transitioned to hybrid models, while the remaining 9 shifted directly to gold OA type. The journal “Biology of Reproduction” provides authors with the option to publish under a standard license, priced at US \$1400, or under an open-access arrangement, priced at US \$4380. It is categorized as a gold OA publication in this study.

To investigate longitudinal trends in publishing within the field of human reproduction, the emergence of newly established journals since 2013 was analyzed. It was observed that 5 out of 9 (55.5%) diamond OA, 4 out of 13 gold OA (30.7%), and 3 out of 19 hybrid access journals—accounting for a total of 12 out of 41 (29.2%), commenced

Table 1 Journals, access types, publishers, and affiliations

	Journal	Access type	Publisher	Affiliation
1	<i>American Journal of Reproductive Immunology</i>	Hybrid	Wiley	American Society for Reproductive Immunology
2	<i>Andrologia</i>	Gold	Hindawi	N/A
3	<i>Andrology</i>	Hybrid	Wiley-Blackwell	The European Academy of Andrology
4	<i>Asian Journal of Andrology</i>	Gold	Wolters Kluwer Health	Asian Society of Andrology
5	<i>Asian Pacific Journal of Reproduction</i>	Diamond	Wolters Kluwer Health	Hainan Medical University
6	<i>Basic and Clinical Andrology</i>	Gold	Springer Nature	French Society of Andrology (SALF)
7	<i>Biology of Reproduction</i>	Gold	Oxford University Press	Society for the Study of Reproduction
8	<i>Clinical and Experimental Reproductive Medicine (CERM)</i>	Diamond	Korean Society for Reproductive Medicine	Korean Society for Reproductive Medicine
9	<i>F and S Reports</i>	Gold	Elsevier	American Society for Reproductive Medicine
10	<i>F and S Reviews</i>	Hybrid	Elsevier	American Society for Reproductive Medicine
11	<i>F and S Science</i>	Hybrid	Elsevier	American Society for Reproductive Medicine
12	<i>Fertility and Reproduction</i>	Diamond	World Scientific Publishing Company	The Official Journal of the Asia Pacific Initiative on Reproduction (ASPIRE)
13	<i>Fertility and Sterility</i>	Hybrid	Elsevier	American Society for Reproductive Medicine
14	<i>Gynecological Endocrinology</i>	Gold	Taylor & Francis	International Society of Gynecological Endocrinology
15	<i>Human Fertility</i>	Gold	Taylor & Francis	British Fertility Society
16	<i>Human Reproduction</i>	Hybrid	Oxford University Press	European Society for Human Reproduction and Embryology (ESHRE)
17	<i>Human Reproduction open</i>	Gold	Oxford University Press	European Society for Human Reproduction and Embryology (ESHRE)
18	<i>Human Reproduction Update</i>	Hybrid	Oxford University Press	European Society for Human Reproduction and Embryology (ESHRE)
19	<i>International Journal of Fertility and Sterility</i>	Gold	Royan Institute	Royan Institute
20	<i>International Journal of Infertility and Fetal Medicine</i>	Diamond	Jaypee Brothers Medical Publishers (P) Ltd	International Institute for Training and Research in Reproductive Health (IIRRH)
21	<i>International Journal of Reproductive BioMedicine</i>	Gold	Research and Clinical Centre for Infertility	Iranian Journal of Reproductive Medicine
22	<i>JBRA Assisted Reproduction</i>	Diamond	Brazilian Society of Assisted Reproduction	Brazilian Society of Assisted Reproduction
23	<i>Journal of Assisted Reproduction and Genetics</i>	Hybrid	Springer Nature	American Society for Reproductive Medicine
24	<i>Journal of Human Reproductive Sciences</i>	Diamond	Wolters Kluwer Health	Indian Society of Assisted Reproduction
25	<i>Journal of Reproduction and Infertility</i>	Diamond	Avicenna Research Institute	<i>Avicenna Research Institute (ARI)</i>
26	<i>Journal of Reproductive Immunology</i>	Hybrid	Elsevier	European Society of Reproductive Immunology
27	<i>Middle East Fertility Society Journal</i>	Diamond	Springer Nature	Middle East Fertility Society
28	<i>Molecular Human Reproduction</i>	Hybrid	Oxford University Press	European Society for Human Reproduction and Embryology (ESHRE)
29	<i>Molecular Reproduction and Development</i>	Hybrid	Wiley-Blackwell	N/A
30	<i>Reproduction</i>	Hybrid	Bioscientifica Ltd	Society for Reproduction and Fertility (SRF)
31	<i>Reproduction and Fertility</i>	Gold	Bioscientifica Ltd	Society for Reproduction and Fertility (SRF)
32	<i>Reproductive Biology</i>	Hybrid	Elsevier	Society for Biology of Reproduction
33	<i>Reproductive and Developmental Medicine</i>	Diamond	Wolters Kluwer Health	Chinese Medical Association
34	<i>Reproductive Biology and Endocrinology</i>	Gold	Springer	N/A
35	<i>Reproductive BioMedicine Online</i>	Hybrid	Elsevier	AAB College of Reproductive Biology
36	<i>Reproductive Medicine and Biology</i>	Gold	Wiley-Blackwell	Japan Society for Reproduction

Table 1 (continued)

Journal	Access type	Publisher	Affiliation
37 <i>Reproductive sciences</i>	Hybrid	Springer Nature	Society for Reproductive Investigation
38 <i>Reproductive toxicology</i>	Hybrid	Elsevier	European Teratology Society
39 <i>Revista Internacional de Andrologia</i>	Hybrid	Elsevier	Asociación Española de Andrología
40 <i>Seminars in Reproductive Medicine</i>	Hybrid	Thieme	N/A
41 <i>Systems Biology in Reproductive Medicine</i>	Hybrid	Taylor & Francis	N/A

publication during this specified timeframe, corresponding to an average of 1 journal per year. Furthermore, it was observed that a notable increase in the proportion of gold and diamond OA journals increased from 42% (13 out of 31) to 53.6 (22 out of 41) by 2023. The distribution of journals by access type, stratified based on commencement of publication before and after 2013, is illustrated in Fig. 1.

Citation metrics between access models

A Kruskal–Wallis test was conducted to determine differences in various citation metrics, including JIF, JCI, CiteScore, SNIP, SJR, quartiles (Q1–Q4), h-index, and percent cited scores, between the hybrid, gold OA, and diamond OA groups. The distribution of citation metric scores appeared similar across all groups, as evidenced by a visual examination of a boxplot. Statistical analysis revealed significant differences in the medians of JCI ($\chi^2 [2]=12.127, p=0.002$), CiteScore ($\chi^2 [2]=9.724, p=0.008$), SNIP ($\chi^2 [2]=7.248, p=0.027$), SJR ($\chi^2 [2]=17.529, p<0.0005$), quartiles (Q1–Q4) according to SJR scores ($\chi^2 [2]=15.677, p<0.0005$), h-index scores ($\chi^2 [2]=18.289, p=<0.0005$), and percent cited scores ($\chi^2 [2]=15.779, p<0.0005$) between the groups. Subsequent

pairwise comparisons using Dunn’s procedure with a Bonferroni correction indicated statistically significant differences in median JCI scores between the hybrid (0.90) and diamond OA (0.29) groups ($p=0.018$), median CiteScore between the hybrid (5.90) and diamond OA (3.10) groups ($p=0.008$), median SNIP between the hybrid (0.959) and diamond OA (0.661) groups ($p=0.04$), and median SJR scores between the hybrid (0.84) and diamond OA (0.35) groups ($p<0.0005$). Significant differences were also observed in the median H-scores between the hybrid (109) and diamond OA (24) groups ($p<0.0005$) and between the gold OA (33.5) and hybrid (109) groups ($p=0.011$). Additionally, the median percent cited scores were notably higher in the hybrid group (80) compared to the diamond OA group (54) ($p<0.0005$). The median quartiles (Q1–Q4) were also significantly higher in the hybrid group (2) compared to the diamond OA group (3) ($p<0.0005$), as well as in the gold OA group (2) compared to the diamond OA group (3) ($p=0.027$).

Correlations between citation metrics

A Spearman correlation analysis was undertaken to explore the relationship between the JIF and CiteScore in human reproduction journals. The findings revealed

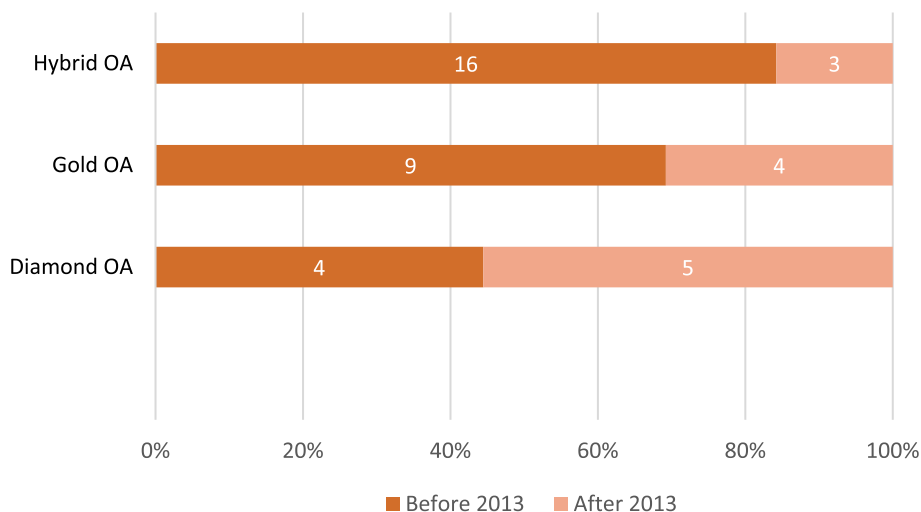


Fig. 1 Number of journals starting publication pre- and post-2013

a robust correlation ($rs=0.937$, $p<0.0005$) between these metrics. Furthermore, comparable correlations were observed between CiteScore and SNIP ($rs=0.690$, $p<0.0005$), as well as between JIF and JCI ($rs=0.848$, $p<0.0005$).

Correlation between APCs and CiteScore

The association between APCs and CiteScore in hybrid and gold OA journals was evaluated using Spearman’s rank correlation. All 19 hybrid journals and 12 out of 13 gold OA journals were found to have a CiteScore. Initial analysis revealed a consistent relationship in both correlation tests, as observed through visual inspection of a scatterplot. A statistically significant, moderately positive correlation was observed between APCs and CiteScore for hybrid journals ($rs(27)=0.515$, $p<0.024$). However, for gold OA journals, no correlation was observed between APCs and CiteScore ($rs(27)=0.445$, $p=0.147$) (Fig. 2).

The data are presented as mean ± standard deviation, unless otherwise specified. An independent samples *t*-test was conducted to investigate differences in APCs between hybrid and gold OA group journals. Inspection

of a boxplot revealed no outliers in the dataset. The APCs for both hybrid and gold OA group journals exhibited normal distribution, as determined by Shapiro–Wilk’s test ($p>0.05$), and demonstrated homogeneity of variances, as confirmed by Levene’s test for equality of variances ($p=0.81$). The mean APCs for all hybrid and gold OA journals were calculated as US \$3032.88 ± 1108.514 (312 to 4430). Specifically, the mean APCs for hybrid OA journals (US \$3617.4 ± 610.19) were significantly greater than those for gold OA group journals (US \$1916.82 ± 988.32), with a difference of 1700.658 (95% CI: 1124.861–2276.455), $t(30)=6.032$, and $p<0.0005$.

Discussion

Hybrid journals constituted nearly half (46.3%) of the journals analyzed, with only three journals started publishing after 2013. In contrast, 40% of gold OA and half of diamond OA journals began publication after this date. However, hybrid journals exhibited significantly higher citation metrics than diamond OA journals. Authors or funders intending to publish in hybrid journals incurred an average cost of US \$1700.6 more compared to gold OA journals. A strong correlation was found between

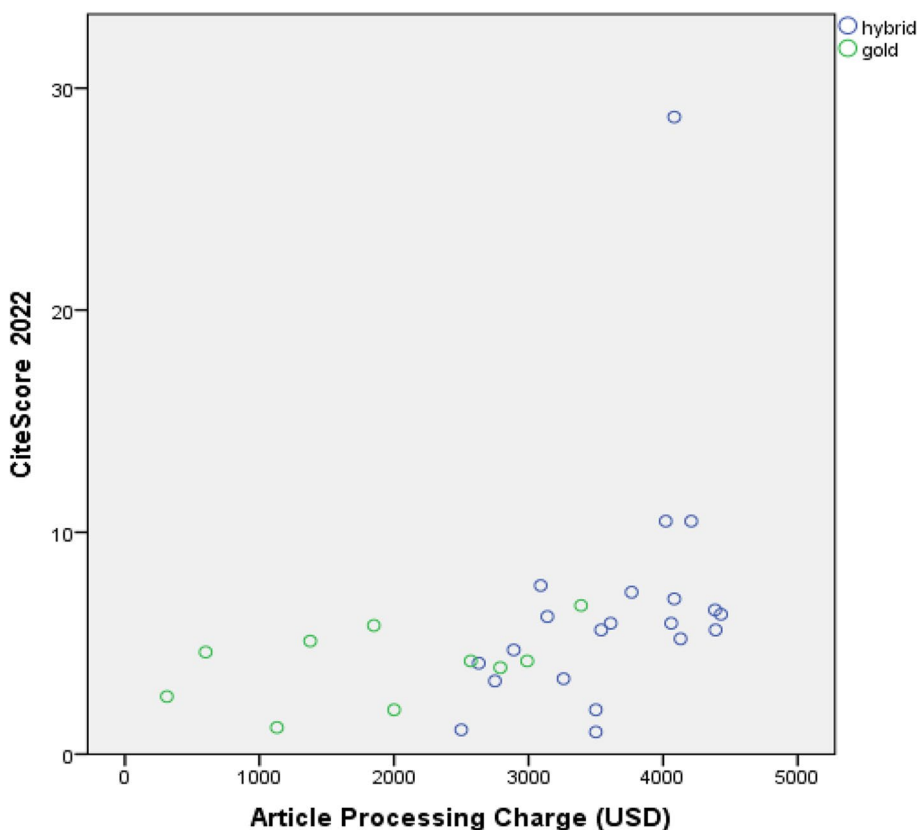


Fig. 2 CiteScore versus APCs for hybrid and gold OA publications. Green data points represent gold OA journals, and blue data points represent hybrid journals. OA, open access; APCs, article processing charges

CiteScore and JIF. Additionally, a positive correlation was observed between APCs and CiteScore for hybrid journals, whereas no such correlation was evident for gold OA journals.

There is a discernible trend favoring OA journals in the realm of human reproduction publishing. Since 2013, 12 journals have been established, with only 3 hybrid journals retaining the option for subscription access articles. There are no subscription access only journals, as all have transitioned to hybrid or gold OA models to remain financially competitive. A substantial number of funders advocate for open-access publishing and disapprove of content being restricted behind paywalls [6, 10]. Additionally, authors may opt for publication in gold OA type due to their comparatively less rigorous peer-review process and faster publication times [8]. These factors have contributed to the increasing prevalence of open-access publishing. Nevertheless, the escalating APCs pose a barrier, excluding researchers with limited financial means or lacking institutional support, thus potentially impeding OA publishing [11]. Notably, there are only nine diamond OA journals (22%), indicative of a disparity for unfunded authors for the payment of APCs. Diamond OA journals emerge as notable platforms as they offer unrestricted access both for reading and publishing [8]. Furthermore, with the advent of the Internet, the publication costs have significantly reduced. All of these factors underscore the considerable potential for expansion within the realm of diamond OA journals.

This study revealed that hybrid journals in the field of human reproduction have higher citation metrics compared to diamond OA journals. However, comparable citation metrics were observed between diamond and gold OA journals. Hybrid journals, initially subscription access, have progressively gained higher citation metrics and prestige over time [12]. Although it is commonly suggested that OA articles receive more citations than subscription access articles, conflicting results have emerged [8, 10, 12]. Future investigations may further explore potential changes in citation metrics among journals with different access types in the forthcoming years.

Journals boasting elevated citation metrics appear attractive to authors seeking publication opportunities. It is reported that authors prioritize the prestige of journals over the magnitude of APCs [8]. In this study, the mean APC for 32 hybrid and gold OA journals was approximately US \$3200, aligning with an emerging industry standard [13]. Nevertheless, gold OA journals offer relatively lower costs [14]. This study demonstrates that publishing a gold OA article in hybrid journals incurs an additional cost of US \$1700 compared to publishing in gold OA journals. However, the assessment of whether human reproduction journals justify the associated APCs

is crucial. Previous studies have reported weak-to-moderate correlations between citation metrics and APCs [7, 8, 15]. In our investigation, we observed only a moderate correlation between APCs and CiteScore for hybrid journals, with no correlation identified for CiteScore in gold OA journals. Consequently, both funders and authors should exercise caution when considering the cost implications of publishing in gold OA journals within the field of human reproduction.

In this study, a significant correlation was observed between CiteScore and JIF, indicating a potential validation of the association between APCs and JIF. However, due to the lack of JIF data for certain journals, particularly those categorized as diamond and gold OA, this specific correlation was not explored. There may exist uncertainty among human reproduction journals regarding the utilization of either of these metrics. Nevertheless, the high correlation between CiteScore and JIF implies their interchangeability. Similar associations between CiteScore and JIF have been observed across various academic fields [16].

This study is subject to several limitations. The study data were restricted to information available on journal websites. Additionally, journals that publish a limited number of articles on human reproduction were not included in the study, as this would deviate from its intended scope. Furthermore, while some journals may offer author discounts, the impact on the results of the statistical analysis is likely minimal. Future research endeavors should explore the perspectives of authors and funders regarding OA publishing, as well as the financial viability of supporting OA publications.

Conclusion

The advent of the Internet has ushered in a new publishing model known as OA, which has introduced a novel approach wherein authors or their sponsors bear the cost. Hybrid journals are almost twice as expensive as gold OA journals. Gold OA journals charge authors regardless of their citation metrics, highlighting the need for caution among authors and funders. The escalating APCs could impede OA publishing, and diamond OA journals represent a valuable opportunity for less funded articles.

Abbreviations

OA	Open access
APCs	Article processing charges
DOAJ	Directory of Open Access Journals
JIF	Journal Impact Factor
JCI	Journal Citation Index
SNIP	Source Normalized Impact per Paper
SJR	SCImago Journal Rank
US\$	US dollars

Acknowledgements

Not applicable

Authors' contributions

HU was the main author responsible for the research and writing and reviewing of the paper. GA, BS, EO, YK, and ED were responsible for data collection. All authors read and approved the final manuscript.

Funding

The authors did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors for the conduct of the study.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Declarations**Ethics approval and consent to participate**

Not applicable.

Consent for publication

All patients have been informed and have consented to publication.

Competing interests

The authors declare that they have no competing interests.

Received: 13 April 2024 Accepted: 2 July 2024

Published online: 10 July 2024

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