Article

Few open access journals are Plan S compliant

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Abstract: Much of the debate on Plan S seems to concentrate on how to make toll access journals open access, taking for granted that existing open access journals are Plan S compliant. We suspected this was not so, and set out to explore this using DOAJ's journal metadata. We conclude that an overwhelmingly large majority of open access journals are not Plan S compliant, and that it is small HSS publishers not charging APCs that are least compliant and will face major challenges with becoming compliant. Plan S need to give special considerations to smaller publishers and/or non-APC-based journals.

Keywords: Plan S, open access journals, APC, technical requirements, publisher size

1. Introduction

Plan S is an initiative for open access publishing that was launched on 4 September 2018. The plan is supported by cOAlition S, which consists of an international consortium of research funders. The coalition, which by 11 December 2018 consists of 13 national funders and 2 charitable foundations, is supported by the European Research Council (ERC) and the European Commission [1]. The plan is structured around 10 principles and the main target is to ensure that all research publications funded by the participating funders are published in compliant open access journals or open access platforms from 1 January 2020 [2]. The members of cOAlition S are also committed to revise the incentive and reward system of science and support the intentions of the San Francisco Declaration on Research Assessment (DORA) [3] which states that journal-based metrics should not be used as a surrogate measure of the quality of individual research articles or individual scientists.

On 27 November 2018 the guidance on the implementation of Plan S [4] was released, clarifying the details for implementation of the initial principles. For scholarly articles to be compliant with Plan S, they must be made openly available immediately upon publication. They must also be published with an open license, limited to Creative Commons Attribution (CC BY), Creative Commons Sharealike (CC BY-SA) or put in the common domain (CC0). The guidance lists three ways in which researchers can publish work that is compliant with the plan. First, authors can publish in compliant open access journals or platforms. Second, a peer reviewed version of articles can be deposited in a compliant repository immediately upon publication. Third, authors can publish open access in subscription journals if the journals are covered by a transformative agreement that includes a commitment to transition to open access. The implementation guidance also lists technical requirements, and guidance, for compliant open access journals, platforms and repositories which will be discussed in the following sections.

Plan S has been much debated since its release and has been met with opposition from a number of researchers and publishers. The Norwegian newspaper Khrono (https://khrono.no/) which covers higher education and research, has since the start of September published more than 50 articles and opinions on the topic. An open letter expressing concerns over Plan S was published on 5 November 2018 [5]. The letter, currently signed by more than 1500, claim that Plan S will limit researchers' freedom to choose publication venue and thus be a serious violation of academic freedom. An other

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open letter in support of funders' open publishing mandates was later released and has currently been signed by more than 1800 [6]. Traditional publishers has been critical of the plan claiming that it may undermine the whole research publishing system and not supporting high quality publishing [7]. Open access publishers have supported the plan and its push for immediate access [8] [9].

While most of the debate has been on academic freedom, quality of research publications and the effect on toll access publishers, there has also been discussions on how the plan might affect open access journals and publishers. In a statement of support the Open Access Publishers Association (OASPA), raises the question of how smaller open access publishers, scholarly societies and innovative new publishing platforms may be placed in disadvantage unless specific provision are made to include them in centralized funding arrangements [10]. OASPA also questions how resources will be made available to open access publications that have different business models than APC, and stress the importance of supporting a range of business models. Leslie Chan, a long-time open access advocate, says that if the APC model becomes the norm it will further existing inequality and points to the need to support a diversity of innovative models and experimentations [11]. Concerns have also been raised about the technical requirements in the implementation guidance of Plan S and how these requirements might affect especially smaller, independent and society published open access journals [12].

In this study we aim to answer the following questions:

1. How many open access journals are currently Plan S compliant?
2. How does compliance relate to publisher size, business model and subject fields?
3. Why are the requirements of Plan S especially challenging for small, non-APC finanzed open access publishers?.

2. Materials and Methods

We base our analysis solely on the Directory of Open Access Journals' (DOAJ) published journal level metadata. This is published as a csv file, a new file version is published every 30 minutes, see https://doaj.org/faq#metadata. We downloaded our file on December 12th 2018, at 14:50 CET. DOAJ is considered the authoritative database of open access journals of scholarly quality.

This file contains data reported by the journals, but for important information this is vetted by DOAJ's corps of editors. We find it safe to assume that data were correct at the time of deposit. We do, however, also feel confident that not all data have been updated to the extent one could hope for, since deposit. We have e.g. during our other work observed that the APC actually charged often differ from the information found in DOAJ. However, the APC amount is information that is often changed, most other information is more stable. We expect, though, that our data could - to some extent - give a more negative picture than what is reality, because journals have improved their situation re the criteria, without remembering to update the journal information in DOAJ. We assume, however, that this is not a major factor. A special case is journals that have changed their status re charging APC or not, this could be a problem especially for journals having no APC in an introductory phase, having since converted to charging APCs.

Some journals have missing information in fields we want to analyse, this is generally more of a nuisance than a problem.

We look at publisher size (Table 1), measured as the number of journals a publisher publishes, as one background variable, because we believe this to influence the capacity and competence to fulfill Plan S requirements. The field "Publisher" in the metadata is used to identify the publisher. There are a number of problems with this, this has been discussed in [13] and we refer the reader to the discussion there.

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Table 1 Publisher size statistics

Publisher size	No of publishers	No of journals	Percentage of publishers	Percentage of journals
1	4446	4446	80 %	36 %
2	522	1044	9 %	8 %
3	187	561	3 %	5 %
4	108	432	2 %	3 %
5	69	345	1 %	3 %
6-10	137	1029	2 %	8 %
11-20	70	1019	1 %	8 %
21-50	33	1002	1 %	8 %
51-100	4	293	0 %	2 %
>100	10	2179	0 %	18 %
	5586	12350	100 %	100 %

Compared to the findings in [13], the smallest publishers measured by the number of journals they publish represent a slightly smaller percentage of publishers (80 percent now and 88 percent then), and a much smaller percentage of the journals (36 per cent now, 55 per cent then) while the larger publishers (50+ journals) have grown from 0.2 per cent of publishers to 0.3, now representing 20 per cent of journals compared to 12.9 per cent then. Larger publishers have become more important to the total volumes published, smaller publishers less important.

The 10 largest publishers are Dove Medical Press (102 journals), Taylor & Francis Group (138 journals), SAGE Publishing (149), Wolters Kluwer Medknow Publications (177), MDPI AG (181), SpringerOpen (197), Hindawi Limited (250), BMC (321), Sciendo (326) and Elsevier (338), a total of 2179 journals or 17.6 per cent of the total number of journals in DOAJ.

SpringerOpen and BMC are both parts of SpringerNature, in addition the Nature Publishing Group has 47 journals, bringing SpringerNature to the top of the list with a total of 565 journals. Sciendo is a publishing service started by De Gruyter, who has 56 journals under their own brand, making Sciendo + De Gruyter with 382 journals the second largest publisher after SpringerNature, with Elsevier in third place. Adding these smaller brands brings the total up to 2282 journals, 18.5 per cent of the total in DOAJ.

Not all Plan S criteria can be discussed through information in these metadata. For this analysis, we assume all criteria that we do not have data about, to be fulfilled. This is of course a major weakness, but any error here will not make the overall situation look better.

3. Results

A main requirement in the implementation guidance is that open access journals must be registered in the Directory of Open Access Journals (DOAJ) to be compliant with Plan S. DOAJ is a directory that indexes and provides access to open access, peer-reviewed journals. To be included in DOAJ, journals must fulfill certain scholarly and technical quality criteria.

The implementation guidance lists technical requirements and recommendations for compliant open access journals and platforms. These are again divided into three sections. The first section 9.1 lists basic mandatory criteria including requirements on copyright, licensing and peer review. Section 9.2 lists mandatory quality criteria which we include in their entirety in Table 1. In addition section 9.3 lists recommended criteria including use of PIDs for authors (such as ORCID), funders, institution and so on. It is also recommended to directly deposit publications to repositories and have accessible and standardized data on citations in accordance with the Initiative for Open Citations.

The technical criteria of Plan S are generally in line with technical industry standards and best practices within scholarly publishing. However, there are probably not many publishers that currently meet every criterion. DOAJ's Principles of Transparency and Best Practice in Scholarly

Publishing covers some of these criteria [14]. Other criteria are covered by the DOAJ seal [15]. To be awarded the DOAJ seal journals have to comply with the following seven conditions:

- use DOIs as permanent identifiers;
- provides DOAJ with article metadata;
- deposits content with a long term digital preservation or archiving program;
- embeds machine-readable CC licensing information in articles;
- allows generous reuse and mixing of content, in accordance with a CC BY, CC BY-SA or CC BY-NC license;
- has a deposit policy registered wíth a deposit policy registry;
- allows the author to hold the copyright without restrictions.

The seal signals that journals adheres to high level of publishing standards and best practice but has nothing to do with the scholarly quality of the material published in the journals [16]. Except for the demand that journals deposit article level metadata with DOAJ and have a deposit policy registered, these criteria are weaker than Plan S criteria, Plan S also has more criteria. Currently there are nearly 1400 journals that have been awarded the Seal [17]. Although a journals inclusion in DOAJ will ensure that some of the mandatory criteria in the implementation guidance are covered, not even the journals awarded the DOAJ Seal can by default be said to fulfill every criterion.

A summary of the criteria in the technical requirements of Plan S, and indication of which criteria can be analyzed using DOAJ journal metadata, is shown in Table 2

Table 2 Summary of criteria and DOAJ journal metadata

	Criterion	Analyzable from DOAJ journal metadata	Comment
A	The journal/platform must be registered in the Directory of Open Access Journals (DOAJ) or in the process of being registered		OK for all journals in the DOAJ
B	The journal/platform must enable authors to publish under a CC BY 4.0 license (alternatively CC BY-SA 4.0 or CC0)	Yes	"Journal license"
C	All scholarly content must be openly accessible (journal website or dedicated platform) and free to read and download immediately upon publication, without any kind of technical or other form of obstacles	Yes	"Does this journal allow unrestricted reuse in compliance with BOAI?"
D	The journal/platform must offer authors/institutions the option of full copyright retention without any restrictions, i.e. no copyright transfer or license to publish that strips the author of essential rights	Yes	"Author holds copyright without restrictions?"
E	The journal/platform must have a solid system in place for review according to the standards within the relevant discipline, and according to the standards of the Committee on Publication Ethics (COPE). Details on this must be openly available through the website.	Yes	"Review process"
F	The journal/platform must provide automatic APC waivers for authors from low-income countries and discounts for authors from middle-income countries	Yes	"Journal waiver policy (for developing country authors etc)"
G	The journal must not have a mirror/sister subscription journal with substantial overlap in editorial board to avoid business models charging for both access and publication.	No	

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	Such journals will de facto be considered hybrid journals (see 'Transformative Agreements' below)		
H	Transparent costing and pricing: information on the publishing costs and on any other factors impacting the publication fees (for example cross subsidizing) must be openly available on the journal website/publishing platform. This must include details on direct costs, indirect costs and potential surplus	No	
I	Use of DOIs as permanent identifiers (PIDs with versioning, for example in case of revisions)	Yes	"Permanent article identifiers"
J	Deposition of content with a long-term digital preservation or archiving programme (such as CLOCKSS)	Yes	"Digital archiving policy or program(s)"
K	Availability of the full text (including supplementary text and data when applicable and feasible) in machine readable format (for example XML), allowing for seamless Text and Data Mining (TDM).	Yes	"Full text formats"
L	Linking to underlying data, code, and so on available in external repositories	No	
M	High quality article level metadata – including cited references – in standard interoperable format, under a CC0 public domain dedication. Metadata must include complete and reliable information on funding provided by cOAlition S funders	No	
N	Machine readable information on the Open Access status and the license embedded in the article	Yes	"Machine-readable CC licensing information embedded or displayed in articles"

We have here identified 14 criteria, of which 4 (G, H, L, M) cannot be analyzed using DOAJ journal metadata, while one (A) is fulfilled by default for any journal found in the DOAJ. We are left with 9 criteria we can analyze – maybe not to perfection, but to a reasonable degree. The wording in the criteria is not necessarily clear and what fulfils them not always self-evident. We still have enough information to be able to do a meaningful analysis.

There are 12 350 journals in our DOAJ metadata file.

Criterion B (license) (Table 3)

This criterion is met by 5831 journals. CC BY, CC BY-SA or Public domain are accepted as OK in our analysis.

Table 3 License compliance

License	Number of journals
CC BY	5091
CC BY-NC	2247
CC BY-NC-ND	2743
CC BY-NC-SA	951
CC BY-ND	139
CC BY-SA	739
Public domain	1
Publisher's own license	409

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(No data available)	30
Total	**12350**

Criterion C (open availability)

This criterion is met by 12151 journals, if we assume that BOAI compliance is what it takes to be compliant with Plan S. The remaining 199 journals have no information about this. However, since compliance with BOAI or publishing with a Creative Commons-license are basic criteria for entry into DOAJ, we will assume all 12350 journals to be compliant in the rest of our analyses.

Criterion D (copyright retention)

56 journals have no information about this. In 6318 journals authors do not retain copyright, while they do retain copyright in 5976 journals.

Criterion E (review) (Table 4)

DOAJ metadata lists 5 different forms of review. We consider all but "Editorial review" or "(No data available)" to be compliant with criterion E. That means 189 of 12350 journals do not meet this criterion, 12161 do.

Table 4 Peer review compliance

Review process	**Number of journals**
Blind peer review	3494
Double blind peer review	6001
Editorial review	133
Open peer review	135
Peer review	2531
(No data available)	56
Total	**12350**

Criterion F (waivers)

DOAJ metadata states whether the journal has a policy, but gives no detail about what the policy is (there is a link to information in the individual journal, though). We assume that all journals having a waiver policy, has a policy that meets the criterion. This is, of course, not necessarily true but time does not allow us to delve to deeply into this.

10047 journals do not have a waiver policy, only 2303 have one, but this is a criterion that is only applicable to APC journals. There are 3244 journals that charge an APC listed in DOAJ, 59 have no APC information. 1400 of the APC-charging journals (or those with no APC information) do not have a waiver policy, 1903 have one.

A strange fact is that 400 journals that state they do not charge APCs still have a waiver policy. Our impression is that the majority of these are open access journals published by larger publishers that publish journals both with and without APCs, possibly also journals that have a 0 APC in an introductory period - and that the waiver information is a general clause inherited by default. For analytical purposes it is not meaningful crediting non-APC-journals for having a waiver policy, this could mess up analyses so we set the waiver policy to "No" for these purposes. Another problem is that not all journals that go from not charging APCs to charging APCs, change their information in DOAJ accordingly.

Criterion I (DOIs)

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The DOI information field in DOAJ metadata contains a lot of various texts, including such as "In the process of acquiring DOI" etc. We consider that all journals where this field has the text string "DOI" in it, meets the criterion. 7209 journals meet this criterion according to our analysis, 5141 do not.

Criterion J (Long-term preservation)

CLOCKSS is the only example mentioned of what meets the criterion. There are more services, and many journals use more than one. We are not wholly certain which of the services mentioned actually meet the criterion, but have decided to include users of the following services that we find in the "Digital archiving policy or program(s)" field as meeting the criterion: LOCKSS, CLOCKSS, PKP LN, Portico, PMC, Europe PMC, PMC Canada. If this is a correct assumption, we have 3627 journals meeting the criterion, 8723 not meeting it.

Among those not meeting this criterion, 2105 journals have a value in the column "Archiving: national library", another 565 in the column "Archiving: other". The first of these columns contains nearly 400 different values, the latter nearly 275. Common to them is that it is difficult to understand the actual service used and there is no information about what this implies, so we have concluded to see these journals as not having documented being Plan S compliant. Plan S will need to define what constitutes an acceptable service, and create a list of compliant services, so that editors and publishers know what services to use.

Criterion K (full-text format)

Again, only XML is mentioned as an acceptable format. From what we understand, HTML is also a format that meets the requirements. We have included journals where the full-text information field contains the strings "HTML" or "XML" as compliant. That gives us 4530 compliant and 7820 non-compliant journals. If only XML is compliant, the numbers change to 1470 compliant and 10879 non-compliant journals.

Criterion N (embedded licensing info)

DOAJ metadata gives us information about whether machine readable CC license information is embedded in the text files. 6610 journals meet this criterion, 5740 do not.

A more general picture

To get a clearer picture, we have given compliance of a criterion the value 1, non-compliance 0. If we then sum these values to a total score, we see to which extent a journal meets all 9 criteria we analyze – 9 being a perfect score, i.e. compliant on all criteria analyzed, 0 being non-compliant on all criteria. For journals not charging APC, 8 is the perfect score as a waiver policy is meaningless for these journals.

We do suspect that there is a correlation between scores and

a. Charging an APC or not
b. The size of the publisher as measured in the number of journals the publisher publish

This is a very general assumption, and a number of journals will show this not to be true on the individual journal level. But some of these criteria cannot be met without financial resources or good publishing competence. Charging an APC gives you a chance to meet financial needs, and publishing many journals enables you to develop publishing competence.

If we look at the total score and how that is distributed depending on whether the journal has an APC or not, we get the picture shown in Table 5.

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Table 5 Sum of compliance and APC status

No of Journals	**Sum of criteria fulfilled (number of journals)**										
APC-based	0	1	2	3	4	5	6	7	8	9	Total
No	2	41	871	2022	2393	1741	1390	332	255		9047
Yes		2	75	229	383	341	347	792	245	830	3244
Total	**39**	**61**	**946**	**2252**	**2777**	**2083**	**1738**	**1124**	**500**	**830**	12350
No of Journals	**Sum of criteria fulfilled (percentage)**										
APC-based	0	1	2	3	4	5	6	7	8	9	Total
No	0 %	0 %	10 %	22 %	26 %	19 %	15 %	4 %	3 %		100 %
Yes		0 %	2 %	7 %	12 %	11 %	11 %	24 %	8 %	26 %	100 %
Total	**0 %**	**0 %**	**8 %**	**18 %**	**22 %**	**17 %**	**14 %**	**9 %**	**4 %**	**7 %**	100 %

The upper part in absolute number, the lower in percentages – each line sums up to 100 per cent.

Only 1085 (8.8 percent) of the journals registered in DOAJ meet all criteria. Of these journals 255 are non-APC journals (score 8) and 830 are APC journals (score 9). 59 per cent of non-APC journals meet 4 or less criteria (less than half of the criteria), while 32 per cent of APC journals meet 5 or fewer criteria (half or less of the criteria). So there is a marked tendency to APC journals meeting more criteria than non-APC journals.

Table 6 Publisher size and sum of criteria compliance

No of Journals	**Sum of criteria fulfilled (number of journals)**										
Publisher size	0	1	2	3	4	5	6	7	8	9	Total
1	13	26	500	1045	1247	908	503	147	41	16	4446
2	13	8	105	236	298	211	118	33	14	8	1044
3	3	2	64	139	146	109	65	18	13	2	561
4			39	115	106	82	32	36	14	8	432
5		3	14	87	99	78	40	17	4	3	345
6-10	2	1	95	243	312	192	121	40	14	9	1029
11-20	3	4	100	228	223	159	134	95	61	12	1019
21-50	4		27	141	254	160	119	97	88	112	1002
51-100			1	17	70	20	46	85	24	30	293
>100	1	17	1	1	22	164	560	556	227	630	2179
Total	**39**	**61**	**946**	**2252**	**2777**	**2083**	**1738**	**1124**	**500**	**830**	**12350**
No of Journals	**Sum of criteria fulfilled (number of journals)**										
Publisher size	0	1	2	3	4	5	6	7	8	9	Total
1	0 %	1 %	11 %	24 %	28 %	20 %	11 %	3 %	1 %	0 %	100 %
2	1 %	1 %	10 %	23 %	29 %	20 %	11 %	3 %	1 %	1 %	100 %
3	1 %	0 %	11 %	25 %	26 %	19 %	12 %	3 %	2 %	0 %	100 %
4	0 %	0 %	9 %	27 %	25 %	19 %	7 %	8 %	3 %	2 %	100 %
5	0 %	1 %	4 %	25 %	29 %	23 %	12 %	5 %	1 %	1 %	100 %

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6-10	0 %	0 %	9 %	24 %	30 %	19 %	12 %	4 %	1 %	1 %	100 %
11-20	0 %	0 %	10 %	22 %	22 %	16 %	13 %	9 %	6 %	1 %	100 %
21-50	0 %	0 %	3 %	14 %	25 %	16 %	12 %	10 %	9 %	11 %	100 %
51-100	0 %	0 %	0 %	6 %	24 %	7 %	16 %	29 %	8 %	10 %	100 %
>100	0 %	1 %	0 %	0 %	1 %	8 %	26 %	26 %	10 %	29 %	100 %
Total	**0 %**	**0 %**	**8 %**	**18 %**	**22 %**	**17 %**	**14 %**	**9 %**	**4 %**	**7 %**	**100 %**

We see from the above (Table 6) that smaller publishers have a larger percentage of their journals in the left part of the table, and fewer in the right, while the larger publishers have few in the left and many in the right part of the table. This means there is a correlation between the publisher size and the ability to comply with the criteria.

HSS/STEM journals

Based on information about "Subjects" in the DOAJ data, we have grouped journals into HSS and STEM journals, except for 14 journals where this information is missing. The field "Subjects" in the metadata file contains information about scholarly field. Alternative classifications are separated by "|", while higher level and lower level subject classifications are separated by ":". We have assumed the first classification to be the most relevant in case of alternative classifications, and have used the high level term (before the first ":") as a classification of subject field. This left us with 20 subjects, which we manually have sorted into HSS and STEM.

Combining this with information on whether journals charge APC or not (excluding 59 where this information is not available and the 14 where subject is lacking) and publisher size in terms of journals published, we get this overview (Table 7).

Table 7 APC and non-APC journals in HSS and STEM sorted by publisher size

Number of journals		HSS/STEM		
Charging APCs?	Publisher size group	HSS	STEM	Total
No	1	2396	1399	3795
	2	551	327	878
	3	297	156	453
	4	200	118	318
	5	170	101	271
	6-10	632	239	871
	11-20	599	259	858
	21-50	457	226	683
	51-100	77	50	127
	>100	210	574	784
No Total		**5589**	**3449**	**9038**
Yes	1	218	416	634
	2	52	99	151
	3	43	61	104
	4	43	70	113
	5	39	35	74
	6-10	61	95	156
	11-20	35	121	156
	21-50	75	238	313
	51-100	19	146	165

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	>100	116	1257	1373
Yes Total		**701**	**2538**	**3239**
Grand total		**6290**	**5987**	**12277**

We see that a majority of journals in DOAJ are non-APC-charging journals, and the majority of them are HSS journals from small publishers. Publishers with 1 or 2 journals have the majority of non-APC HSS journals, the situation is nearly the same for non-APC STEM journals. Among the APC-charging journals, the vast majority are among STEM journals. And the larger publishers publish a large part of the journals, especially in STEM. So we are looking at a world characterized by many small HSS publishers publishing without charging APC, and fewer and larger STEM publishers, financing activities by charging APCs.

Meeting the criteria

The 14 different criteria we have identified differ significantly in what is needed to comply. Some criteria can be met by making the right policy decisions; some need competence and some degree of funding to enable journals to meet them. Criterion A and C can be said to be fulfilled by default by being registered in DOAJ. Meeting criterion B, D, E, F, G, and H is mostly a question of policy, although some would argue that providing information on publishing cost is not straight forward [12]. Criterion I, J, K, L, M, N are reliant on available technical infrastructure and technical competence, or funding to buy external services.

We can group the criteria we can analyze through the metadata into Policy requirements (B, C, D, E and F) and Technical requirements (I, J, K and N) leaving A as default and not being able to analyze G, H, L or M.

Policy requirements are generally a matter of taking the right decisions, technical requirements need competence and/or financial resources to comply with.

If we look at policy criteria (Table 8), we find that there is not much difference between APC-charging journals and non-APC-charging journals. Remember: Non-APC-charging journals only have 4 policy criteria to comply with, APC-charging 5 (waiver policy).

Table 8 Policy criteria compliance and publisher size

Number of journals	Number of policy criteria met						
APC or not/Publisher size	0	1	2	3	4	5	Total
No	**3**	**107**	**3103**	**3646**	**2188**		**9047**
1	1	57	1286	1502	954		3800
2		19	272	391	197		879
3		3	162	189	99		453
4		3	93	153	69		318
5		3	62	119	87		271
6-10	1	6	294	377	194		872
11-20	1	10	283	306	260		860
21-50		5	204	328	146		683
51-100		1	17	107	2		127
>100			430	174	180		784
Yes		**5**	**408**	**1177**	**631**	**1023**	**3244**
1		5	148	238	166	77	634
2			36	49	50	16	151
3			22	43	25	14	104
4			17	31	49	17	114

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5			15	27	16	16	74
6-10			41	60	34	21	156
11-20			47	72	21	16	156
21-50			25	98	62	130	315
51-100				50	37	79	166
>100			57	509	171	637	1374
Total	**3**	**112**	**3511**	**4823**	**2819**	**1023**	**12291**

If we look at the technical criteria, we get a different picture (Table 9).

Table 9 Technical criteria compliance and publisher size

Number of journals	Number of technical criteria met					
APC or not/Publisher size	0	1	2	3	4	Total
No	**2400**	**2988**	**1835**	**1127**	**697**	**9047**
1	1214	1362	823	350	51	3800
2	268	319	199	79	14	879
3	147	166	87	38	15	453
4	111	113	73	16	5	318
5	90	110	37	30	4	271
6-10	228	348	219	47	30	872
11-20	227	261	200	99	73	860
21-50	97	243	157	120	66	683
51-100	17	65	6	32	7	127
>100	1	1	34	316	432	784
Yes	**289**	**490**	**373**	**463**	**1629**	**3244**
1	152	214	131	93	44	634
2	30	38	44	22	17	151
3	17	42	22	12	11	104
4	21	36	8	22	27	114
5	14	20	27	7	6	74
6-10	23	56	35	18	24	156
11-20	20	32	22	22	60	156
21-50	9	48	25	36	197	315
51-100	3	4	48	36	75	166
>100			11	195	1168	1374
Total	**2689**	**3478**	**2208**	**1590**	**2326**	**12291**

We see that most non-APC-charging journals satisfy only a few of the technical criteria, while a majority of APC-charging journals satisfy them all. And we also see that the level of compliance increases with publisher size, for both APC-charging and non-APC-charging journals.

One could argue that running a journal should require a certain competence and that scholars would be better served not publishing in journals failing to meet basic technical standards or missing basic technical or publishing competence. However, it is important to note that these technical requirements are not related to the scholarly quality of the published content. Only one of the Plan S criteria addresses scholarly quality. Criterion E says that journals/platforms must have a solid system

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in place for review according to standards within the relevant discipline and COPE. As we have already established almost all journals registered in DOAJ meet this criterion.

Discussion

The size distribution of open access publishers has been analyzed by Frantsvåg [13]. In his analysis of journals indexed in DOAJ, he found that almost 90 percent of publishers only publish a single journal, amounting to 55 percent of all journals, while larger publishers with more than 10 journals only constitute 1 percent of publishers but publish 23.3 percent of journals. This distribution has been largely confirmed in a new study [18]. There are challenges for small publishers related to economy, efficiency and expertise. By looking at how single journal publishers adhere to some of the principles of best practice in DOAJ, it is possible to draw some conclusions on how these challenges are manifested. Frantsvåg [13] investigates how many journals deliver article metadata to DOAJ and finds that less than half of the registered journals do. Having the article metadata in DOAJ is an efficient method for disseminating the research and free and fairly easy to do. However, many small publishers do not use this functionality. In 2014 DOAJ introduced new criteria for inclusion and required journals that were already registered to reapply before April 2016, in order to be kept in the registry. Looking at journals that were removed from DOAJ after April 2016, Frantsvåg [18] finds that the single journal publishers lost nearly one third of journals while the percentage of lost journals steadily decrease in relation to publishers' size. It is important to note that the removal of journals has little to do with scholarly quality but is primarily a result of failure to reapply. This leads to the conclusion that many small publishers seem to have lacked the competence or resources necessary to understand or go through the re-application process.

The implementation guidance of Plan S state that cOAlition S "does not favor any specific business model for Open Access publishing or advocate any particular route to Open Access given that there should be room for new innovative publishing models" [4]. The coalition also "explicitly acknowledges the importance of a diversity of models and non-APC based outlets". However, as we see in our data, the requirements clearly favors APC-based publishers.

Conclusion

The goal of Plan S is full and immediate open access to publications from publicly funded research. To achieve this there must be available publishing venues that are aligned with this goal. There has been much debate among researchers on the consequences Plan S might have in limiting their opportunity to publish in traditional (and prestigious) toll access journals. As evident in this study the requirements in the implementation guidance of Plan S might also have an adverse effect on available open access journals. And it is clear that APC-based large publishers are much better placed to make themselves Plan S compliant than are small, non-APC-based publishers.

Limiting our study to the 10 criteria we can analyse using DOAJ-metadata, we find that 8.8 percent (1085 of 12350) of open access journals meet all of these criteria. Fulfillment of the remaining 4 criteria might result in even fewer Plan S compliant open access journals. Furthermore there is a clear relation between journals charging APC, publisher size and the ability to comply with the criteria. Only 2.8 percent of non-APC journals and 25.6 percent of APC journals meet all criteria. Looking at academic disciplines it is clear that the humanities and social sciences will be most affected since the open access journals in these segments are usually smaller and free to publish in.

We have not studied the open access journals of the countries most heavily "affected" by Plan S, but this is not trivial. Many open access journals can live well without be compliant, as long as they do not have a market among authors with Plan S financing. Increasingly, as more funders or countries join Plan S, not being compliant will create problems for the journals - and for their authors. A quick look at e.g. Dutch language, Finnish language or Norwegian language journals will reveal that they have some way to go before they can expect manuscripts from Plan S funded authors.

We are not arguing that these requirements should not be made. But we want to warn that the current timeline will pose a threat to a number of open access journals of good scholarly quality that

scholars do not want to lose. The current time-line will remove the non-APC-journals from the market, leaving the APC-based journals the winners.

Some recommendations to cOAlititon S:

- Invest in technical infrastructure that will enable journals to meet the technical requirements. The tools must be freely available, open source and not require a high level of technical competence to use. For instance the publishing system OJS is currently used by almost 5000 journals in DOAJ. Supporting the development of OJS to be able to deliver on all of the requirements would be an efficient and inexpensive way to enable many journals to be Plan S compliant.
- Consider the possibility of different technical requirements for APC and non-APC journals, or at least different time-frames for implementation of the requirements, possibly with different dates for different requirements. As it is still unclear what some of the requirements imply, even competent publishers may not know how to position themselves to be Plan S compliant. For the smaller publishers, the current time-frame is impossible to comply with.
- Plan S need to find or develop, and finance, services that can certify Plan S compliant journals. In order to do that, one needs to define what are acceptable responses to the requirements about text format and archiving. The Plan S certification service will also need to certify the archiving services and define the acceptable text formats, in order to be able to certify Plan S-compliant journals.

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Conflicts of interest:

Jan Erik Frantsvåg is a member of MDPI Publications editorial board and the DOAJ advisory board. He is also engaged in the University Library publishing service, Septentrio Academic Publishing, which publishes non-APC open access journals.

Tormod Eismann Strømme is engaged in the University Library publishing service, Bergen Open Access Publishing, which publishes non-APC open access journals.

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