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Article Placement Order in Rheumatology Journals: A Content Analysis

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Abstract

Objectives. To analyse variables associated with article placement order in serial rheumatology journals.

Design. A content analysis of original articles published in seven rheumatology journals from 2013-2018.

Methods. The following data were extracted from 6,787 articles: order number of article in issue, gender of first and last author, geographical region, industry funding, and disease category. Cumulative density function plots were used to determine whether article placement distribution was different from the expected distribution. Odds ratios for articles published in the first three places of an issue compared with the last three places were calculated. Altmetric score and downloads were meta-analysed.

Results. Article placement order did not associate with author gender, geographical region or funding source, but was associated with disease category. Articles about rheumatoid arthritis were more likely to be ordered at the front of issues ($P<0.001$). Articles about crystal arthritis, systemic lupus erythematosus, vasculitis, pain syndromes and pediatric rheumatic diseases were more likely to be ordered at the end of issues (all $P<0.001$). Association of article placement order with disease category was observed only in journals with tables of contents grouped by disease. Articles ordered in the first three places had higher Altmetric and download rates, than articles in the last three places.

Conclusions. Author gender, geographical region, or funding source do not influence article placement order in serial rheumatology journals. However, bias for certain disease categories is reflected in article placement order. Editorial decisions about article placement order can influence the prominence of diseases.

Keywords: publication, bias, rheumatology

Strengths and limitations of the study

- This is the first study to assess the relationship of article placement order in serial medical journals with author gender, geographical region of affiliated institution, industry funding or disease category.
- This content analysis included 6,787 articles from general rheumatology journals.
- This study also analysed the impact of article placement order on research prominence, including Altmetric scores and download rate.
- This analysis did not explore other factors that may have contributed to article placement order such as the originality of the study findings or the presence of "star" authors.

INTRODUCTION

The strong preference for items ordered first, and the important effect of list order on choice, is well-recognised in consumer-based research.[1-3] In online searches for health information, 97% of selected links were displayed in the first 10 results, while only 2% were from the second or following pages.[4] For online academic repositories, earlier listed articles were downloaded more frequently than later listed articles.[5] These primacy effects, which increase when lists are longer,[6] may occur because earlier items, or those at the top of tables of contents, are more visible and more likely to be seen and read.[5]

In academic publishing, the ordering of articles within a journal issue also affects the prominence achieved by that research. Earlier listed articles received more citations over a 25 year period in a single journal.[7] The impact of ordering was also evident in an analysis of emails sent to subscribers disseminating recent research papers listed in random order; with the first paper having a 33% increase in views, 29% increase in downloads and 27% increase in citations, regardless of research quality.[8]

A number of systemic biases have been reported in academic publishing. These include preferential lead and senior authorship of men,[9, 10] higher acceptance rates for articles from the US and Europe,[9, 11] preferential publication of industry-funded research,[12] and disease privileging, wherein particular diseases receive preferential research funding and publication.[13-15] It is unknown whether these systemic biases are reflected in article placement order within medical journals. We analysed serial rheumatology journals for relationships between article placement order and gender of the lead and senior authors, geographical region of the affiliated institution, industry sponsorship, and disease category.

METHODS

Patient and public involvement

There was no patient or public involvement in the design, or conduct, or reporting, of this research.

Identification of journals and articles for inclusion

This was a cross-sectional content analysis of original articles published in general rheumatology journals. Journals were included if they produced regular issues, reported original research and had 2016 Thomas Reuters Impact Factors of > 3.0. Journals were excluded if they published review articles only, were disease-specific (e.g. *Lupus*, *Osteoarthritis and Cartilage*) or produced no issues. The following seven general rheumatology journals met the above criteria and were included: *Annals of the Rheumatic Diseases, Arthritis & Rheumatology, Arthritis Care & Research, Seminars in Arthritis and Rheumatism, Rheumatology, Journal of Rheumatology*, and *Joint Bone Spine*. Characteristics of the included journals are shown in **Supplementary Table 1**.

All original articles published in the included journals in a five-year period from June 2013 to June 2018 were included in the analysis. To be included, articles could be full or concise reports, and report on original basic science or clinical research, including systematic reviews and meta-analyses. Articles were excluded if they were from a disease-specific thematic issue or supplement, were narrative reviews, recommendations, guidelines, letters, or meeting reports.

Data extraction

Data extraction was undertaken between June and December 2018. The following information was extracted for each included article: order number of article in the issue, gender of lead (first) author; gender of senior (final) author; geographical region of affiliated institution (for the first author); any industry sponsorship (industry-funded and initiated/industry-funded and investigator-initiated/not industry-funded); and, if available, the Altmetric score and number of downloads. The number of citations was not assessed because of the short time period between publication and data extraction. If author gender could not be determined by first name or by an internet search of the author's affiliated institution profile page, then the author's first name was entered into https://api.genderize.io/?name= which returns the gender and probability of certainty. Probabilities < 0.5 were labelled as "unknown" and not included in the gender-related analysis. If articles were authored by a single author, then this author's gender was entered under first author. Funding was assessed by review of funding statements, disclosures and author affiliations. Industry-funded studies were categorized as industry-funded and industry-initiated, or industry-funded and investigator-initiated, based on these statements. Studies with no evidence of industry funding were categorized as not industry-funded.

Articles were coded according to the following 13 disease categories: ankylosing spondylitis and other spondyloarthropathy, crystal arthritis, osteoarthritis, miscellaneous rheumatic disease, pediatric rheumatology, pain syndromes, psoriatic arthritis, rheumatoid arthritis, systemic lupus erythematosus, systemic sclerosis/scleroderma, other connective tissue disorders, vasculitis, and not disease-specific. The title of each article was used to determine the disease category. If there was uncertainty about the disease category from the title, then the abstract and/or full paper were reviewed.

To ensure standardisation in data extraction, two authors (SS, ND) independently reviewed eligible papers from ten randomly selected issues. A total of 208 articles were reviewed, with

kappas of 1.00 for author gender, geographic region and industry funding, while disease category had a kappa of 0.84 (86.1% agreement (95% confidence interval (CI) 81.0%, 90.5%)). All disease category disagreements were discussed to reach a consensus and a set of rules for categorising was established. The exercise was then repeated in which the two authors reviewed disease categories in a further five randomly selected issues totalling 85 articles, with a kappa of 0.99 (98.8% agreement (95% CI 94.3%, 99.9%)) for disease category. A single reviewer (SS) then independently extracted the data.

Data analysis

The primary analyses assessed the relationships between article placement order and: gender of first authors, gender of last authors, geographical region (North America vs. Europe vs. Other), industry funding categories (industry-funded and initiated vs. industry-funded and investigator-initiated vs. not industry-funded), and disease categories. In order to identify whether these factors were associated with article placement order within journal issues with different numbers of articles, each article within each issue was assigned a standard article placement index (SAPI), which was defined as the order of the article in the issue/total number of articles in the issue. For example, the first article in an issue of 21 articles was given an SAPI of 1/21 = 0.0476 and the last article 21/21 = 1. Cumulative distribution functions (CDF) were analysed to determine the associations between article placement order and author gender, geographical region industry funding and disease category. A uniform distribution would be expected if there was no association with article placement order: skewed deviations from the expected uniform distribution would support an association with article placement order. To test whether the distribution of SAPIs were different between author genders, geographical regions, and industry funding categories, two-sample

Kolmogorov-Smirnov Z tests were conducted. Effect sizes (*D*) were computed with values ranging from 0 (no difference in distribution of SAPI between comparisons) to 1 (large difference in distribution of SAPI between comparisons). To determine whether the distribution of SAPIs for each disease category was different from a uniform distribution CDF (expected distribution if no bias reflected in article placement order), the area under the curve (AUC) of the observed CDF and uniform distribution CDF were each calculated using a trapezoidal method and the difference between these estimated for each of the 13 disease categories. Mean differences between the observed CDF and the uniform distribution CDF were computed from bootstrapped samples (500 replicates, sampled with replacement) and 95% confidence intervals estimated as the 2.5th and 97.5th percentile of the bootstrap distribution. P-values were calculated for each disease category from these confidence intervals using the method of Altman and Bland.[16]

A secondary analysis was undertaken to further explore article placement order, in which mid-P exact P-values were computed to compare the proportion of articles appearing in at least one of the first three places of an issue compared to at least one of the last three places of an issue for genders of first and last authors, geographical region, industry funding category, and each disease category. Odds ratios (OR) and their 95% CIs were also computed for articles in the first three places vs. last three places of an issue.

As some journals presented their content grouped by disease category, additional analyses were undertaken to determine whether article placement order of disease categories was different between journals which presented content grouped by disease category vs. journals without disease category content grouping. This was tested statistically using CDF plots of SAPI distributions, two-sample Kolmogorov Smirnov Z tests and effect sizes (D) as described above.

Finally, to determine the impact of article placement order on Altmetric scores and article download rates (as available), meta-analyses were used to determine differences in the means for each variable between the first and last three articles in journal issues. Altmetric scores were provided by *Arthritis & Rheumatology, Annals of the Rheumatic Diseases*, *Rheumatology* and *Arthritis Care & Research*. *Annals of the Rheumatic Diseases*, *Rheumatology* and *The Journal of Rheumatology* had article download data available, but for the latter two journals, the data were available in only the 6 months prior to data extraction. Therefore, analyses of article downloads were undertaken for *Annals of the Rheumatic Diseases* only. For Altmetric scores, which generally do not change over time, mean scores were calculated by total Altmetric scores/total number of articles. For downloads, which are time dependent, rates were calculated by total number of downloads/total article-years from time of publication to time of data extraction. These analyses were undertaken within disease categories, adjusted by journal, as appropriate, and weighted using the inverse-variance method. Random effects models were used for all I^2 values > 0%.

All analyses were performed in SPSS (v25 IBM Corp), SAS v9.4 (SAS Institute Inc, Cary, NC) and openepi.com (v3.01). All tests were two-tailed and false discovery rate (FDR)-adjusted *P* values[17] were computed for all analyses with an alpha level of < 0.05 considered significant.

RESULTS

Characteristics of included articles

A total of 6,787 articles were included. First authors were male in 3250 (47.9%) articles, female in 3517 (51.8%) articles and unknown in 20 (0.3%) articles. Last authors were male in 4412 (65.0%) articles, female in 2359 (34.8%) articles and unknown/not applicable in 16

(0.2%) articles. 596 (8.8%) articles were industry-funded and initiated, 640 (9.4%) were industry-funded and investigator-initiated, and 5551 (81.8%) were not industry-funded. The geographical region was North America in 2177 (32.1%) articles, Europe in 3486 (51.4%) articles, and Other in 1124 (16.6%) articles. Disease categories were rheumatoid arthritis (n = 1946, 28.7%), osteoarthritis (n = 773, 11.4%), systemic lupus erythematosus (n = 642, 9.5%), ankylosing spondylitis (n = 496, 7.3%), pediatric rheumatology (n = 443, 6.5%), systemic sclerosis (n = 433, 6.4%), not disease-specific (n = 422, 6.2%), vasculitis (n = 362, 5.3%), other connective tissue disease (n = 339, 5.0%), miscellaneous (n = 277, 4.1%), crystal arthritis (n = 269, 4.0%), psoriatic arthritis (n = 242, 3.6%), and pain syndromes (n = 143, 2.1%). The specific diseases which were categorised under crystal arthritis, other connective tissue disease, and miscellaneous are shown in **Supplementary Table 2**.

Distribution of article placement within issues

Inspection of the cumulative distribution function plots showed no association of article placement order with author gender, geographical region, or industry funding (**Figure 1**). However, differences in article placement order were observed for disease category (**Figure 2** and **Table 1**). Articles about rheumatoid arthritis were more likely to be placed towards the front of issues. The placement of articles about ankylosing spondylitis, osteoarthritis and psoriatic arthritis conformed to a uniform distribution. Articles about systemic lupus erythematosus, other connective tissue diseases, crystal arthritis, systemic sclerosis, vasculitis, pediatric rheumatology and pain syndromes were more likely to be placed towards the back of issues.

Table 1. Difference in distribution of standard article placement indices (SAPI) from a uniform distribution for each disease category

	N (%)	SAPI, mean (SD)	Difference in AUC between CDF and uniform distribution	
			Mean (95% confidence interval)[a]	FDR-adjusted *P*
Ankylosing spondylitis	496 (7.3%)	0.51 (0.24)	+0.001 (-0.022, +0.014)	0.94
Crystal arthritis	269 (4.0%)	0.63 (0.28)	-0.134 (-0.141, -0.110)	**<0.001**
Miscellaneous	277 (4.1%)	0.68 (0.29)	-0.182 (-0.205, -0.150)	**<0.001**
Not disease-specific	422 (6.2%)	0.61 (0.30)	-0.092 (-0.103, -0.069)	**<0.001**
Osteoarthritis	773 (11.4%)	0.49 (0.24)	+0.002 (-0.014, +0.021)	0.88
Other connective tissue diseases	339 (5.0%)	0.62 (0.25)	-0.110 (-0.127, -0.090)	**<0.001**
Pediatric rheumatology	443 (6.5%)	0.69 (0.28)	-0.190 (-0.230, -0.180)	**<0.001**
Pain syndromes	143 (2.1%)	0.69 (0.27)	-0.183 (-0.260, -0.152)	**<0.001**
Psoriatic arthritis	242 (3.6%)	0.53 (0.24)	-0.012 (-0.045, 0.015)	0.55
Rheumatoid arthritis	1946 (28.7%)	0.36 (0.28)	+0.144 (+0.141, +0.157)	**<0.001**
Systemic lupus erythematosus	642 (9.5%)	0.58 (0.21)	-0.073 (-0.087, -0.050)	**<0.001**
Systemic sclerosis	433 (6.4%)	0.64 (0.24)	-0.140 (-0.147, -0.122)	**<0.001**
Vasculitis	362 (5.3%)	0.65 (0.24)	-0.154 (-0.180, -0.122)	**<0.001**

AUC = area under the curve; CDF = cumulative density function; SAPI = standard articles placement index. [a]*Positive differences indicate deviations from a uniform distribution above the uniform distribution function (i.e. article skewed towards the front of an issue),while negative differences indicate deviations from a uniform distribution below the uniform distribution function (i.e. article skewed towards the back of an issue).*

Articles in the first and last three places of an issue

There were no significant differences in the proportion of articles in the first vs. last three places of an issue for author gender, geographical regions, or industry funding category (**Supplementary Table 3**). However, consistent with the cumulative distribution function analysis, differences for disease category were observed (**Figure 3 and Supplementary Table 3**). There was a significantly greater proportion of articles in the first three compared to the last three places of an issue for rheumatoid arthritis (35.6% vs. 8.7% $P < 0.001$) with an OR (95% CI) of 5.77 (4.80, 6.92). There was a similar proportion of articles in the first three and last three places of an issue for ankylosing spondylitis, osteoarthritis, or psoriatic arthritis. There was a significantly lower proportion of articles in the first three compared to the last three places of an issue for crystal arthritis (10.8% vs. 26.8%), other connective tissue diseases (6.8% vs., 16.5%), pediatric rheumatology (8.4% vs. 38.8%), pain syndromes (8.4% vs. 37.1%), systemic lupus erythematosus (4.7% vs. 9.7%), systemic sclerosis (4.4% vs. 18.2%) and vasculitis (6.4% vs. 18.0%) (all $P \leq 0.001$).

Journals with and without content grouped by disease category

Arthritis & Rheumatology, *Seminars in Arthritis and Rheumatism*, *Arthritis Care & Research* and *The Journal of Rheumatology* grouped issue content by disease category with disease-specific tables of contents sections, while *Annals of the Rheumatic Diseases*, *Rheumatology*, and *Joint Bone Spine* did not group issue content by disease category (**Supplementary Table 1**). Journals with content grouped by disease showed an association between article placement order and disease category, whereas this was less evident for journals without content grouped by disease (**Figure 4**). Comparisons between journals with and without content grouped by disease category demonstrated a significant difference in the SAPI

distributions for every disease category, with articles on rheumatoid arthritis placed towards the front of issues, and articles on crystal arthritis, pain syndromes, pediatric rheumatology, systemic sclerosis and vasculitis placed towards the end of issues, in journals with content grouped by disease category (**Supplementary Table 4**).

The impact of article placement order on Altmetric scores and downloads

The impact of article placement order was evident in the meta-analysis results, which showed a higher Altmetric score (adjusted for journal) for articles published in the first three places of an issue compared with the last three, (mean difference in Altmetric score of 5.11, 95% CI 1.50, 8.71, Z = 2.78, *P* = 0.005) (**Figure 5**). The difference in Altmetric scores varied across different disease categories (I^2 76%; *P* < 0.001), with the largest difference between positioning in the first three places and positioning in the last three places being observed for articles about rheumatoid arthritis and psoriatic arthritis.

Similarly, meta-analysis showed that articles published in the first three places of an issue had a higher download rate compared to articles in the last three places of an issue (pooled rate difference (95% CI) 442.1 (293.0, 591.2) downloads/article year, Z = 5.81, *P* < 0.001) (**Figure 5**). The difference in download rate between the first and last three articles was similar across different disease categories (I^2 24%; *P* = 0.21).

DISCUSSION

In this analysis of serial rheumatology journals, no relationship between article placement order and author gender, geographical region or industry sponsorship was observed. However, differences for disease category were apparent, with more frequent positioning of

articles about rheumatoid arthritis towards the front of journal issues, and articles about crystal arthritis, other connective tissue diseases, pediatric rheumatology, pain syndromes, systemic lupus erythematosus, systemic sclerosis and vasculitis towards the back of issues. Analyses of Altmetric scores and download rates suggested that article placement order influences research prominence, with earlier placed articles receiving more attention.

Medical journals are central to evidence-based practice and represent a key source of new knowledge for medical professionals.[18, 19] Unbiased publication practices are important in allowing a variety of perspectives and emphases to expand the scope of research and clinical practice. Although bias has been previously reported in academic journals based on authorship ordering of genders,[9, 10] representation of geographical regions,[9, 11] and acceptance and time to publication based on industry sponsorship,[12] our analysis showed that these factors were not associated with article placement order within serial rheumatology journals.

Articles about rheumatoid arthritis were preferentially placed towards the front of rheumatology journals, while other conditions, particularly pain syndromes, crystal arthritis, pediatric syndromes, and connective tissue diseases, were ordered towards the back. Rheumatoid arthritis was the disease category with the greatest number of articles, therefore giving it the greatest opportunity to be listed first, but our analyses accounted for the variation in article numbers between disease categories. Although rheumatoid arthritis is a very important rheumatic disease,[20] general rheumatology practice involves the diagnosis and treatment of a wide range of diseases.[21, 22] General rheumatology journals should ideally reflect that diversity of clinical practice. A similar distribution of articles on each disease category would therefore be expected if there was no bias for disease category.

The reason for the observed differences in article placement for disease category is unclear. Disease privileging in other fields of medical research has been reported, with some prevalent diseases with high global impact being under-funded and under-researched.[13-15] Crystal arthritis, osteoarthritis and pain syndromes are common and have high global burden,[23-25] but may be viewed by rheumatologists and journal editors as less important or less severe.[26, 27] These perceptions of some rheumatic diseases have the potential to impact attitudes in clinical practice and contribute to lower quality of care.[27, 28] Rheumatic diseases such as vasculitis, pediatric rheumatic disease, and scleroderma are less common, but can lead to major morbidity and reduced quality of life. Improving the impact and accessibility of research published on 'lower priority' or less common rheumatic diseases may have an important impact on clinicians' understanding about and attitudes towards these conditions in clinical practice.

Differences in article placement order for disease category was particularly evident in journals with disease-specific tables of contents sections within issues, rather than journals that did not group issue content by disease category. It has been suggested that grouping article content by disease category may improve the reader experience.[29] However, such decisions have the potential to further reduce readers' exposure to diseases that are already under-studied or less well understood. Editorial decisions to remove grouping by disease category, or to cycle the order of disease category groups for each issue may be a simple solution to overcome bias for disease category reflected in article placement order.

In our analysis, articles appearing in the first three places of an issue had higher Altmetric scores and download rates compared to articles appearing in the last three places of an issue. This is consistent with prior studies which also demonstrate the impact of the primacy effect on research prominence.[6-8] Collectively, these findings indicate that articles placed at the front of journal issues receive greater prominence. The prominence and impact of research

published in journals has an important role in not only providing information to improve knowledge and treatment, but also in financing further research[30] and obtaining academic promotion.[31]

The current analysis has some limitations. Firstly, Altmetric and download data were not available from all journals included in the analysis, and it is unclear whether similar differences are present across all journals. Secondly, citation rates were not evaluated because of the short time period between article publication and data extraction which would not have reflected true citation rates, which increase over time. Finally, this analysis did not explore other factors that may have contributed to article placement order such as quality, impact, or originality of the study, or the presence of prolific or "star" authors.[32]

In conclusion, author gender, geographical region, or funding source do not influence article placement order in serial rheumatology journals. However, bias for certain disease categories is reflected in article placement order. Article placement order may have an impact on research prominence, including Altmetric scores and download rate. Editorial choices about the serial position of articles within journals can influence prioritisation of certain diseases.

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Competing interests

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Author contributions

SS contributed towards acquisition, analysis and interpretation of the data. GG contributed towards design of the study and analysis and interpretation of the data. AG contributed towards design of the study and interpretation of the data. ND contributed towards design of the study, and acquisition and interpretation of the data. All authors were involved in drafting of the work or revising it critically for important intellectual content. All authors approved the final version to be published and agree to be accountable for all aspects of the work.

Data statement

All extracted data used in the analyses are available upon reasonable request from the corresponding author.

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Figure legends

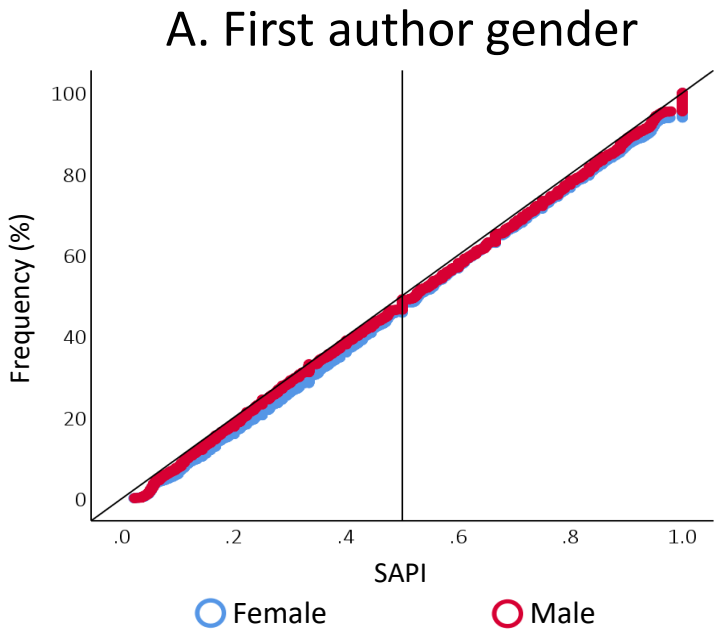
Figure 1. Cumulative distribution function plots of standardised article placement indices (SAPI) for first author gender (**A.**), senior author gender (**B.**), industry funding (**C.**), and first author's geographic region of affiliated institution (**D.**). Left skewed distributions suggest prioritisation towards the front of journal issues.

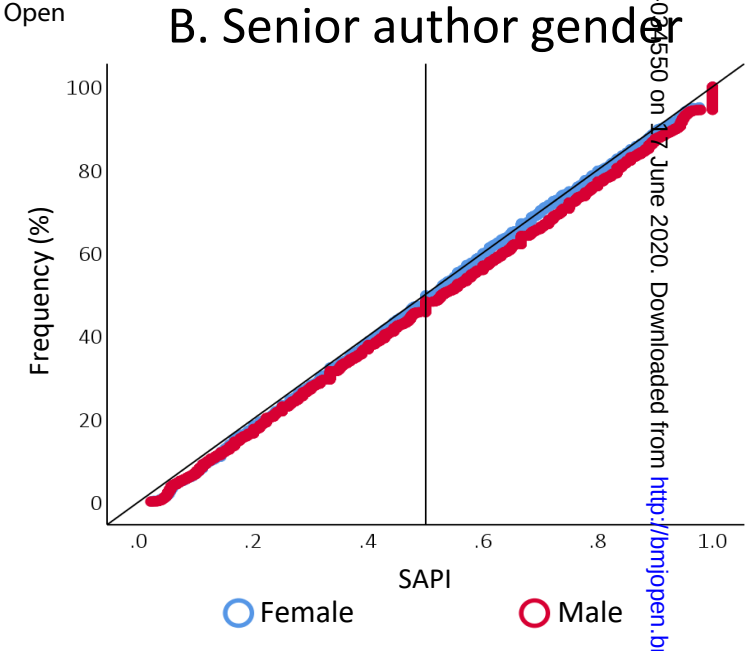
Figure 2. Cumulative distribution function plots of standardised article placement indices (SAPI) for each disease category. Left skewed distributions suggest prioritisation towards the front of journal issues.

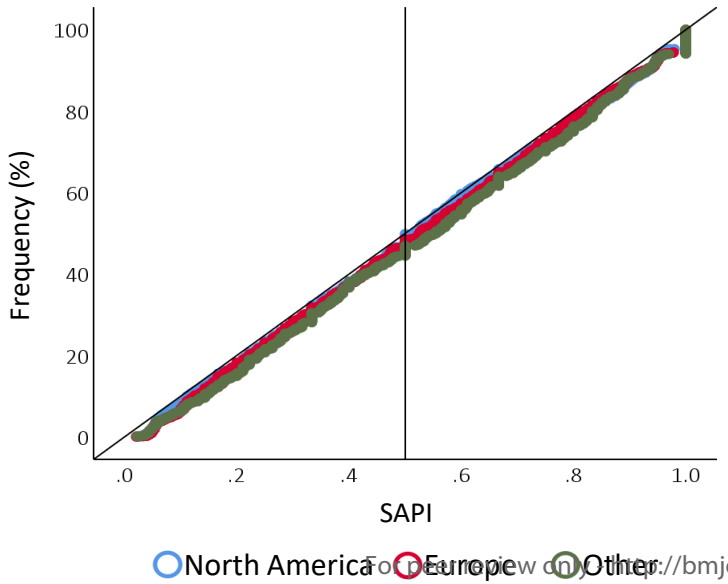
Figure 3. Percentage of articles (per disease category) published in first three and last three places of an issue (*P*-values indicate difference between proportions of articles in first and last three places of an issue).

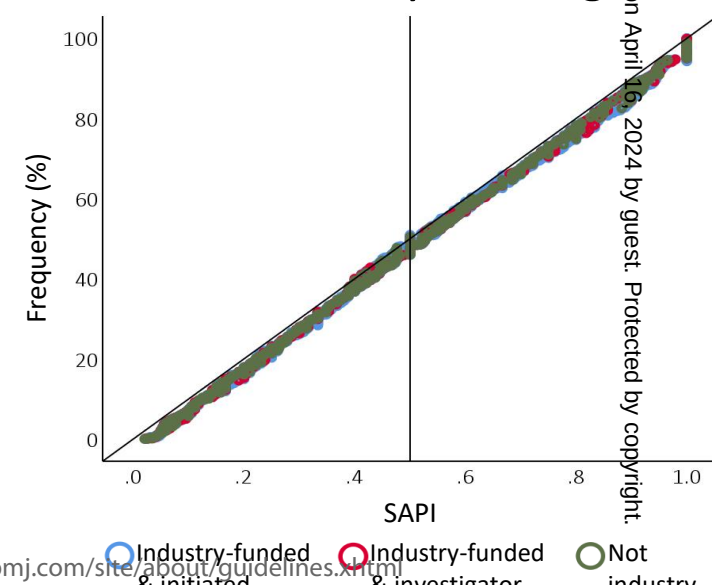
Figure 4. Cumulative distribution function plots of standardised article placement indices (SAPI) for each disease category for journals with (**A.**) and without (**B.**) contents grouped by disease. Left skewed distributions suggest prioritization towards the front of journal issues.

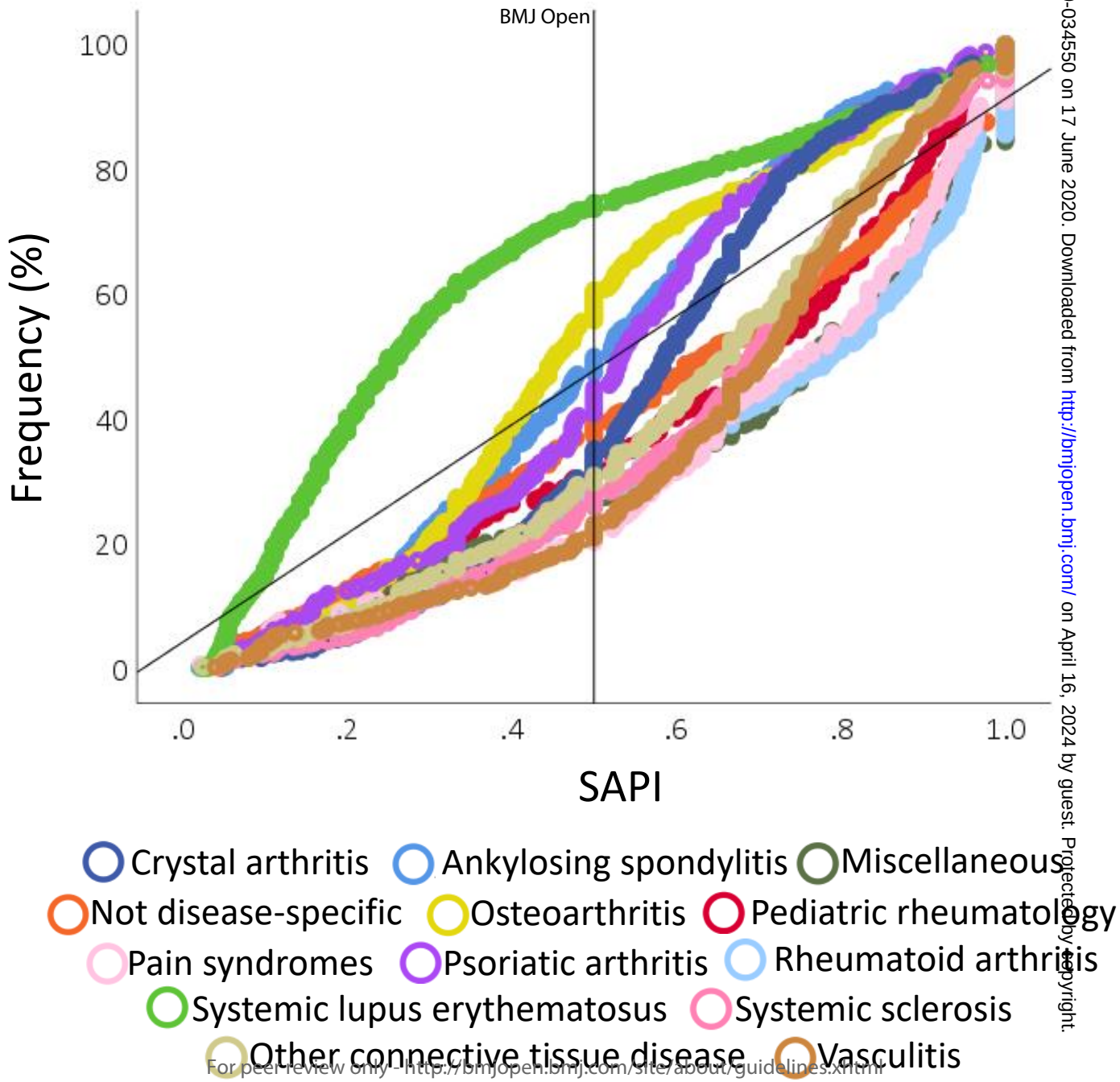
Figure 5. Forest plots showing the mean differences for each disease category for Altmetric scores (**A.**) and download rates (**B.**) between articles published in the first vs. last three places of an issue. Positive differences indicate a higher Altmetric score/download rate for articles published in one of the first three places of an issue. Differences in Altmetric scores are adjusted for journal. Download data was available from one journal. CTD: connective tissue disease.



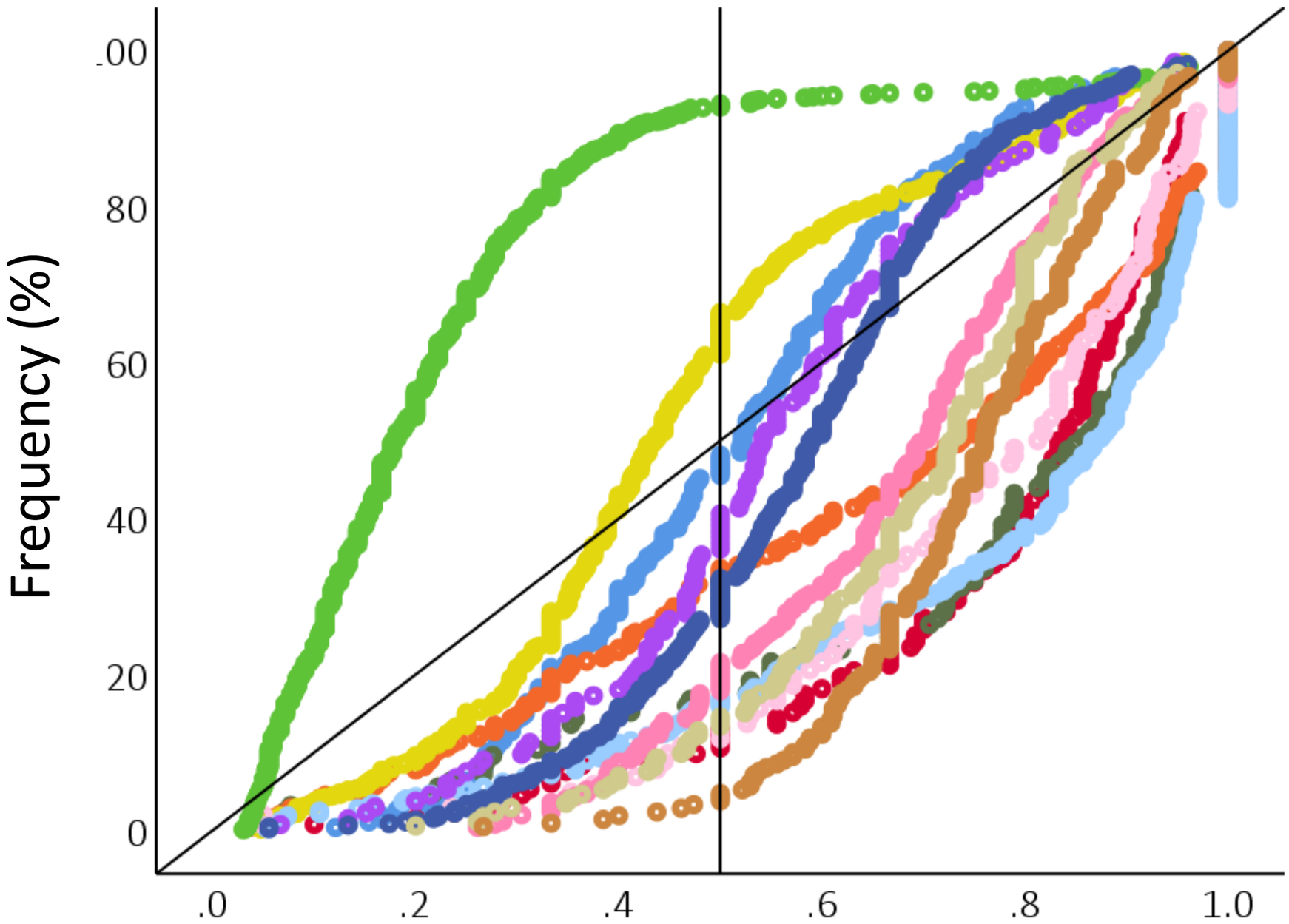




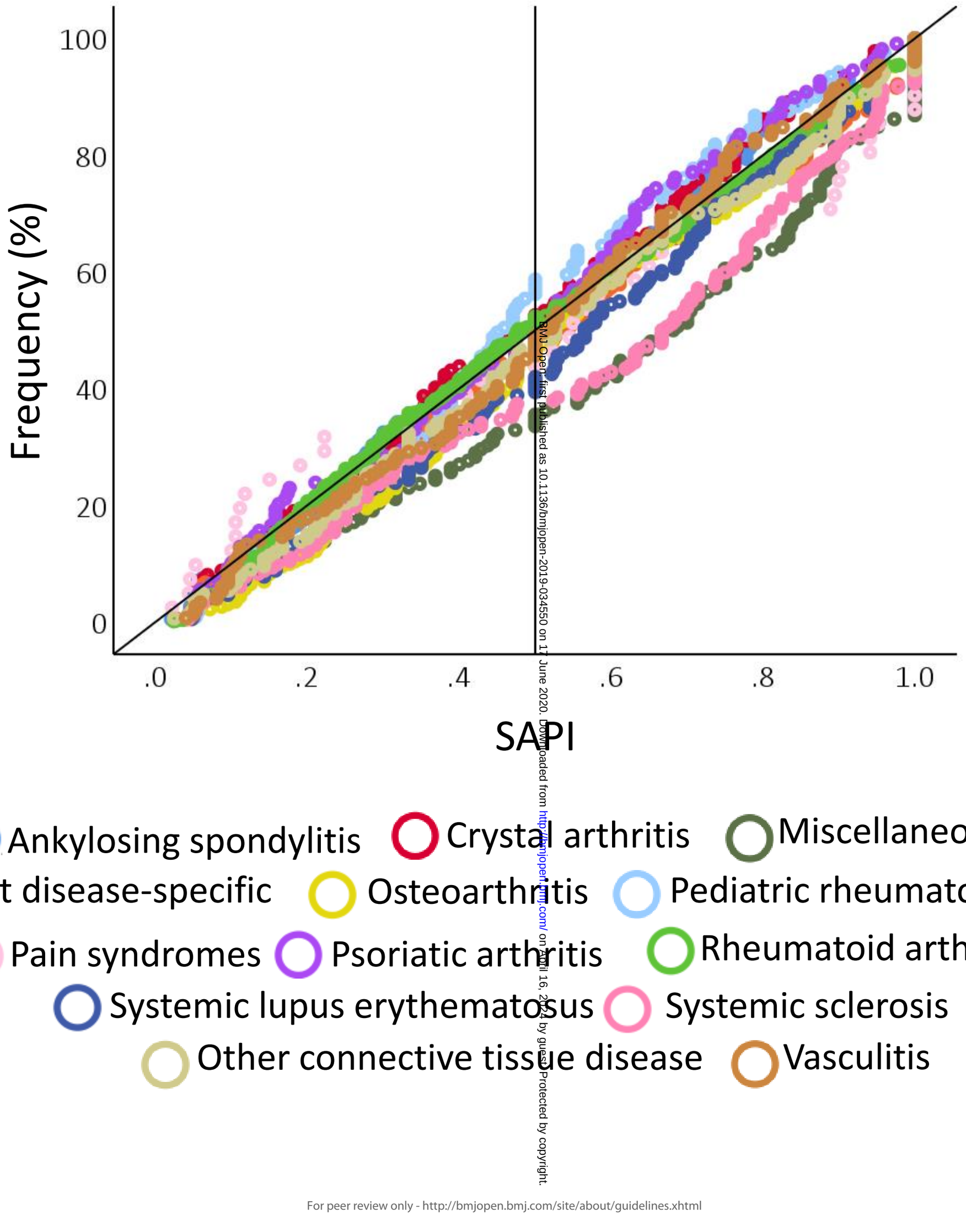


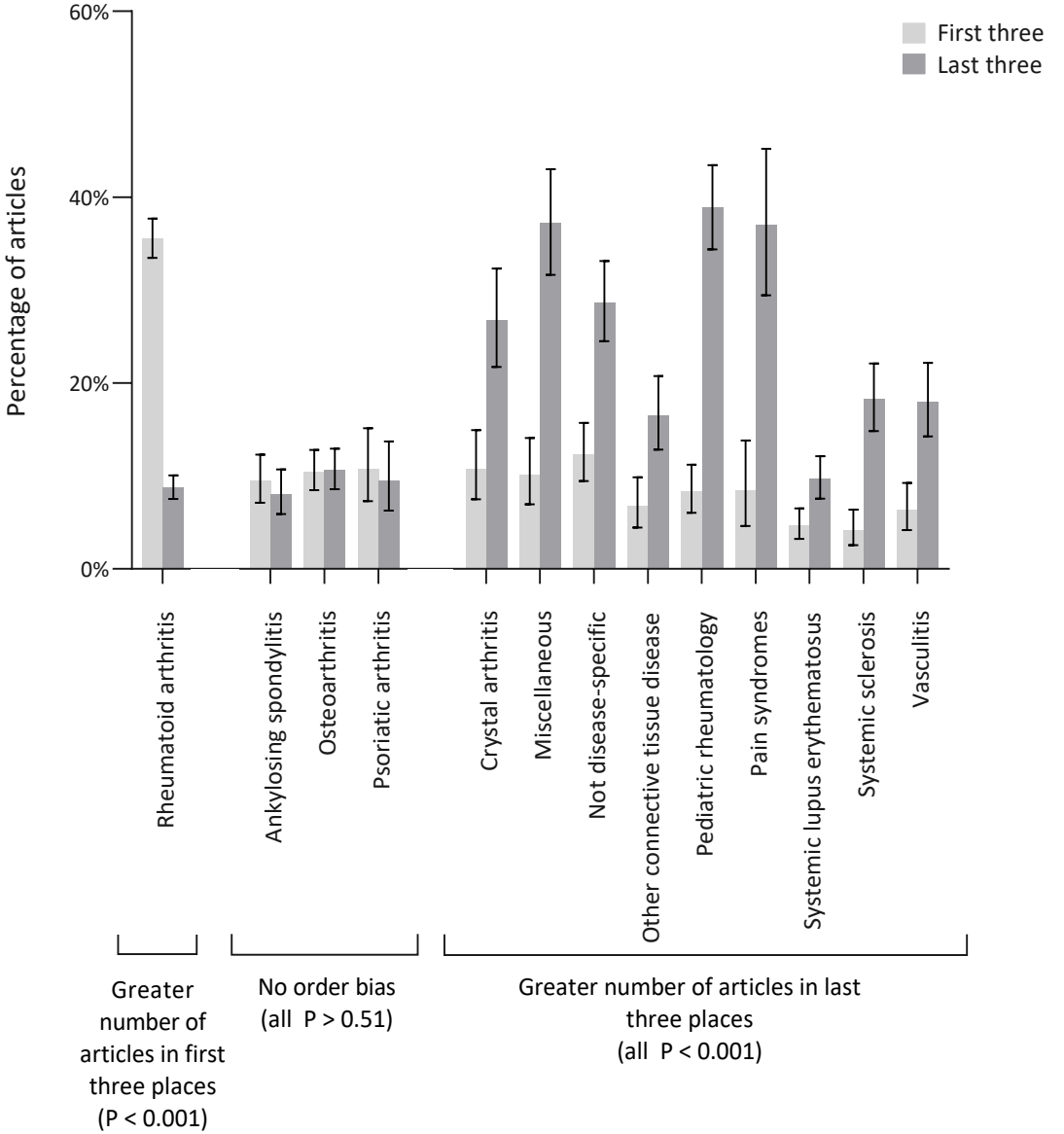


A. Journals with issue content grouped by disease



B. Journals without issue content grouped by disease

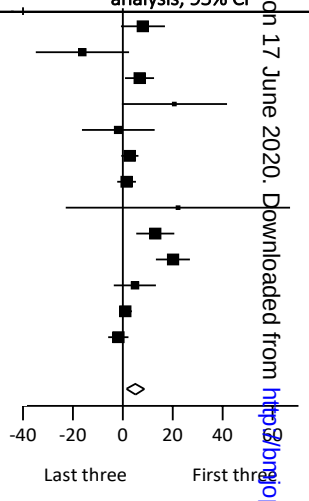



60%
40%
20%
0%
Percentage of articles
First three
Last three
Rheumatoid arthritis
Ankylosing spondylitis
Osteoarthritis
Psoriatic arthritis
Crystal arthritis
Miscellaneous
Not disease-specific
Other connective tissue disease
Pediatric rheumatology
Pain syndromes
Systemic lupus erythematosus
Systemic sclerosis
Vasculitis
Greater number of articles in first three places (P < 0.001)
No order bias (all P > 0.51)
Greater number of articles in last three places (all P < 0.001)

A. Differences in Altmetric scores between articles in first and last three places of an issue

	First three		Last three			Score		Mean difference, random effects analysis, 95% CI
	Mean score	N	Mean score	N	Weight	difference	95% CI	
Ankylosing spondylitis	14.19	32	6.10	31	7.44%	8.09	(-0.70, 16.88)	
Crystal arthritis	9.10	21	25.23	39	2.90%	-16.14	(-34.85, 2.58)	
Miscellaneous	10.95	20	4.18	50	9.93%	6.77	(0.99, 12.55)	
Not disease-specific	28.47	36	7.73	66	2.40%	20.74	(-0.33, 41.82)	
Osteoarthritis	18.47	47	20.26	47	4.20%	-1.79	(-16.35, 12.77)	
Other CTDs	6.421	19	3.57	47	11.91%	2.85	(-0.58, 6.27)	
Pediatric rheumatology	7.14	29	5.57	86	11.63%	1.57	(-2.21, 5.35)	
Pain syndromes	48.36	11	26.10	29	0.61%	22.26	(-22.78, 67.30)	
Psoriatic arthritis	13.00	17	3.00	17	8.38%	13.06	(5.46, 20.65)	
Rheumatoid arthritis	24.16	434	4.03	156	9.01%	20.13	(13.29, 26.97)	
Systemic lupus erythematosus	12.59	27	7.69	58	7.69%	4.90	(-3.55, 13.36)	
Systemic sclerosis	3.88	17	2.81	69	12.50%	1.07	(-1.49, 3.63)	
Vasculitis	2.68	22	4.41	37	11.42%	-1.72	(-5.77, 2.33)	
Total		**732**		**732**	**100.0**	**5.11**	**(1.50, 8.71)**	

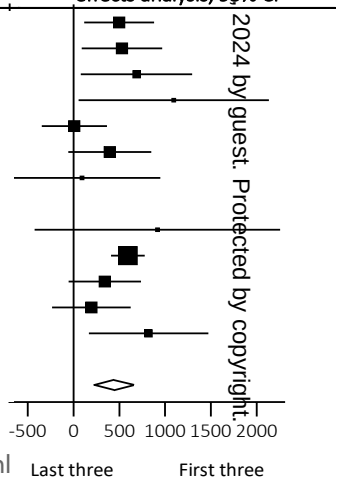
Heterogenity: $Tau^2 = 25.3$; $Chi^2 = 49.8$; $I^2 = 75.9\%$ ($P < 0.001$)
Test for overall effect: Z = 2.78; P = 0.005



B. Differences in download rates between articles in first and last three places of an issue

	First three		Last three			Rate		Mean difference, random effects analysis, 95% CI
	Mean score	N	Mean score	N	Weight	difference	95% CI	
Ankylosing spondylitis	842.8	17	344.9	10	10.9%	497.9	(115.6, 880.3)	
Crystal arthritis	726.3	9	198.1	5	8.88%	528.3	(89.2, 967.3)	
Miscellaneous	1073.5	7	385.3	12	5.18%	688.1	(78.7, 1297.6)	
Not disease-specific	1430.0	15	336.0	15	1.95%	1093.9	(54.7, 2133.1)	
Osteoarthritis	465.5	13	457.2	22	12.04%	8.2	(-347.9, 364.4)	
Other CTDs	785.3	5	389.1	14	8.40%	396.2	(-58.7, 851.1)	
Pediatric rheumatology	758.2	6	626.0	4	3.07%	132.2	(-683.7, 948.1)	
Pain syndromes	1110.5	3	346.4	1	0.00%	Excluded		
Psoriatic arthritis	1408.0	14	491.8	3	1.20%	916.2	(-426.3, 2258.7)	
Rheumatoid arthritis	952.2	76	358.8	54	24.23%	593.4	(409.2, 777.6)	
Systemic lupus erythematosus	880.0	11	538.7	12	10.36%	341.3	(-54.6, 737.2)	
Systemic sclerosis	480.6	5	286.8	25	9.19%	193.9	(-235.4, 623.1)	
Vasculitis	961.3	3	142.0	6	4.59%	819.3	(165.95, 1472.7)	
Total		**183**		**184**	**100.0**	**442.1**	**(293.0, 591.2)**	

Heterogeneity: $Tau^2 = 15400$; $Chi^2 = 14.4$; $I^2 = 23.7\%$ ($P = 0.211$)
Test for overall effect: Z = 5.81; P < 0.001



SUPPLEMENTARY MATERIAL

Supplementary Tables

Supplementary Table 1. Journal characteristics

	Publisher	Country of publication	2016 Impact Factor	Relevant affiliated society	Issues per year	Contents grouped by disease	Total number of articles included, n	Number of included articles per issue, mean (SD)
Annals of the Rheumatic Diseases	BMJ Publishing Group Ltd	United Kingdom	12.811	European League Against Rheumatism	12	No	1374	13.2 (9.4)
Arthritis & Rheumatology	John Wiley & Sons	United States	6.918	American College of Rheumatology	12	Yes	1367	12.5 (7.6)
Rheumatology	Oxford University Press	United Kingdom	4.818	British Society for Rheumatology	12	No	1158	10.2 (5.7)
Seminars in Arthritis and Rheumatism	Elsevier	United States	4.498	None	6	Yes	403	7.3 (4.1)
Joint Bone Spine	Elsevier	United States	3.329	French Society of Rheumatology	6	No	239	4.6 (2.6)
Arthritis Care & Research	John Wiley & Sons	United States	3.319	American College of Rheumatology, Association of Rheumatology Health Professionals	12	Yes	1098	9.6 (5.4)
The Journal of Rheumatology	Journal of Rheumatology Publishing Company Limited	Canada	3.150	Canadian Rheumatology Association	12	Yes	1148	10.3 (6.1)

Supplementary Table 2. Number of articles within each disease category for crystal arthritis, miscellaneous and other connective tissue diseases

	Frequency	Percent
Crystal arthritis **(n = 269)**		
Gout	260	96.7
Calcium crystal diseases	9	3.3
Miscellaneous Disease **(n = 277 articles)**		
Regional musculoskeletal syndromes	48	17.3
Osteoporosis	22	7.9
IgG4-related disease	20	7.2
FMF	20	7.2
Polymyalgia rheumatica	19	6.9
CAPS	16	5.8
Still's disease	10	3.6
Septic arthritis	8	2.9
Fibrosis	8	2.9
Sarcoidosis	7	2.5
Chikungunya Virus	7	2.5
SAPHO syndrome	6	2.2
TRAPS	5	1.8
Polychondritis	5	1.8
Ehlers-Danlos Syndrome	4	1.4
Lyme disease	4	1.4
Alkaptonuria	4	1.4
Hemophagocytic syndromes	3	1.1
Vertebral fractures	2	0.7
Uveitis	2	0.7
Undifferentiated arthritis	2	0.7
Tuberculosis	2	0.7
Periodic fever syndrome	2	0.7
Löfgren syndrome	2	0.7
Erdheim-Chester disease	2	0.7
Dupuytren's disease	2	0.7
ACPA-negative undifferentiated arthritis	1	0.4
Yellow fever	1	0.4
Whipple disease	1	0.4
Vertebral endplate lesions	1	0.4
Tumoral calcinosis	1	0.4
Tenosynovial giant cell tumor	1	0.4
Systemic autoinflammatory disease (SAID)	1	0.4
Schnitzler's syndrome	1	0.4
Ribbing disease	1	0.4
Receptor-associated periodic syndrome	1	0.4
Pyogenic sterile arthritis pyoderma gangrenosum and acne (PAPA) syndrome	1	0.4
Pyogenic arthritis	1	0.4
Primary angiitis of the CNS	1	0.4
Preeclampsia	1	0.4
Pigmented villonodular synovitis	1	0.4
Periodic fever, aphthous stomatitis, pharyngitis, and cervical adenitis (PFAPA) syndrome	1	0.4

Paraneoplastic rheumatic syndrome	1	0.4
Palindromic rheumatism	1	0.4
Paget's disease	1	0.4
Osteonecrosis	1	0.4
Osteomyelitis	1	0.4
NOD2-associated autoinflammatory diseases	1	0.4
Muckle-wells syndrome	1	0.4
Mikulicz's disease	1	0.4
Mevalonate kinase deficiency	1	0.4
Medial meniscal tears	1	0.4
Macrophage activation syndrome	1	0.4
Leri's pleonosteosis	1	0.4
Kikuchi-Fujimoto disease	1	0.4
Joint hypermobility syndrome	1	0.4
Immune reconstitution inflammatory syndrome	1	0.4
Hereditary recurrent fever syndromes	1	0.4
Hereditary haemochromatosis	1	0.4
Haploinsufficiency of A20	1	0.4
Glomerulonephritis	1	0.4
Gaucher disease	1	0.4
Femoral fractures	1	0.4
Fabry disease	1	0.4
Ebola virus	1	0.4
Discitis	1	0.4
Chronic graft-versus-host disease	1	0.4
Blau syndrome	1	0.4
Biphosphate trochanteric fracture	1	0.4
Amyloidosis	1	0.4
Aicardi-Goutières syndrome	1	0.4
Other connective tissue disease **(n = 339 articles)**		
Sjogren's syndrome	174	51.3
Inflammatory myositis	115	33.9
Antiphospholipid syndrome	41	12.1
Mixed connective tissue disease	7	2.1
CTD-associated interstitial lung disease	1	0.3
Undifferentiated connective tissue disease	1	0.3

Supplementary Table 3. Number of articles appearing in at least one article in first and last three articles of an issue for author gender, geographical region of affiliated institution, industry funding category, and disease category

	Total articles	First three N	% of total	Last three N	% of total	Odds ratio (OR)[a]	95% CI for OR	*P*[b]
First author gender								
Female	3517	537	15.3%	586	16.7%	0.90	0.79, 1.02	0.17
Male	3250	557	17.1%	509	15.7%	1.11	0.98, 1.27	0.17
Last author gender								
Female	2359	393	16.7%	355	15.0%	1.13	0.97, 1.32	0.17
Male	4412	705	16.0%	737	16.7%	0.95	0.85, 1.01	0.37
Geographical region of affiliated institution (first author)								
North America	2177	362	16.6%	352	16.2%	1.03	0.88, 1.21	0.68
Europe	3486	573	16.4%	556	16.0%	1.04	0.91, 1.18	0.68
Other	1124	163	14.5%	190	16.9%	0.83	0.66, 1.05	0.35
Industry funding								
Industry-funded and initiated	640	104	16.3%	109	17.0%	0.95	0.70, 1.27	0.71
Industry-funded and investigator-initiated	596	87	14.6%	111	18.6%	0.75	0.55, 1.01	0.09
Not industry-funded	5551	907	16.3%	878	15.8%	1.04	0.94, 1.15	0.09
Disease category								
Ankylosing spondylitis	496	47	9.5%	40	8.1%	1.19	0.77, 1.86	0.51
Crystal arthritis[c]	269	29	10.8%	72	26.8%	0.33	0.21, 0.53	**<0.001**
Miscellaneous	277	28	10.1%	103	37.2%	0.19	0.12, 0.30	**<0.001**
Not disease-specific	422	52	12.3%	121	28.7%	0.35	0.24, 0.50	**<0.001**
Osteoarthritis	773	81	10.5%	82	10.6%	0.99	0.71, 1.37	0.934
Other connective tissue diseases	339	23	6.8%	56	16.5%	0.37	0.22, 0.61	**<0.001**
Pediatric rheumatology	443	37	8.4%	172	38.8%	0.14	0.10, 0.21	**<0.001**
Pain syndromes	143	12	8.4%	53	37.1%	0.16	0.08, 0.31	**<0.001**
Psoriatic arthritis[c]	242	26	10.7%	23	9.5%	1.15	0.63, 2.07	0.71
Rheumatoid arthritis	1946	692	35.6%	170	8.7%	5.77	4.80, 6.92	**<0.001**
Systemic lupus erythematosus	642	30	4.7%	62	9.7%	0.46	0.29, 0.72	**0.001**
Systemic sclerosis	433	18	4.4%	79	18.2%	0.19	0.11, 0.33	**<0.001**
Vasculitis	362	23	6.4%	65	18.0%	0.31	0.19, 0.51	**<0.001**

[a]The odds of being in at least one article in the first three places of an issue; [b]FDR-adjusted Mid-P exact P-value. Bolded values indicate significance at < 0.05. [c]One article in each of 'Crystal arthritis' and 'Psoriatic arthritis' came from issues which included 5 articles and were therefore counted in both the 'first' and 'last' three categories.

Supplementary Table 4. Difference in cumulative density function distribution of standard article placement indices (SAPI) between journals with and without contents grouped by disease for articles with related editorials and for each disease category

	Journals with contents not grouped by disease			Journals with contents grouped by disease			Two-sample Kolmogorov-Smirnov Z test[b]	
	N (%)	SAPI[a]		N (%)	SAPI[a]		Effect size (D)	FDR-adjusted P
		Mean	SD		Mean	SD		
Ankylosing spondylitis	228 (8.2%)	0.49	0.28	268 (6.7%)	0.52	0.19	0.20	**<0.001**
Crystal arthritis	137 (4.9%)	0.49	0.28	132 (3.3%)	0.78	0.20	0.50	**<0.001**
Miscellaneous	152 (5.5%)	0.62	0.30	125 (3.1%)	0.76	0.26	0.29	**<0.001**
Not disease-specific	178 (6.4%)	0.53	0.30	244 (6.1%)	0.66	0.29	0.22	**<0.001**
Osteoarthritis	231 (8.3%)	0.55	0.27	542 (13.5%)	0.47	0.22	0.20	**<0.001**
Other connective tissue diseases	167 (6.0%)	0.49	0.29	172 (4.3%)	0.70	0.17	0.36	**<0.001**
Pediatric rheumatology	121 (4.4%)	0.48	0.26	322 (8.0%)	0.77	0.25	0.50	**<0.001**
Pain syndromes	41 (1.5%)	0.54	0.35	102 (2.5%)	0.75	0.21	0.36	**0.001**
Psoriatic arthritis	109 (3.9%)	0.48	0.27	133 (3.3%)	0.56	0.20	0.22	**0.005**
Rheumatoid arthritis	881 (31.8%)	0.51	0.29	1065 (26.5%)	0.23	0.20	0.49	**<0.001**
Systemic lupus erythematosus	193 (7.0%)	0.56	0.28	449 (11.2%)	0.58	0.17	0.19	**<0.001**
Systemic sclerosis	182 (6.6%)	0.60	0.30	251 (6.3%)	0.68	0.18	0.26	**<0.001**
Vasculitis	151 (5.4%)	0.51	0.28	211 (5.3%)	0.75	0.14	0.50	**<0.001**

[a]Lower SAPI scores equate to articles ordered at the front of issues, while higher SAPI scores equate to articles ordered at the end of issues. [b]Test of difference in distribution of SAPI between journals with and without contents grouped by disease sections. Bolded P-values indicated significant difference at < 0.05.

BMJ Open

Article Placement Order in Rheumatology Journals: A Content Analysis

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-034550.R1
Article Type:	Original research
Date Submitted by the Author:	11-Dec-2019
Complete List of Authors:	Stewart, Sarah; The University of Auckland, Medicine Gamble, Greg; University of Auckland, Department of Medicine Grey, Andrew; University of Auckland Dalbeth, Nicola; University of Auckland,
Primary Subject Heading:	Rheumatology
Secondary Subject Heading:	Evidence based practice
Keywords:	publication, bias, RHEUMATOLOGY

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Article Placement Order in Rheumatology Journals: A Content Analysis

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Word count: 3208

Abstract

Objectives. To analyse variables associated with article placement order in serial rheumatology journals.

Design. A content analysis of original articles published in seven rheumatology journals from 2013-2018.

Methods. The following data were extracted from 6,787 articles: order number of article in issue, gender of first and last author, geographical region, industry funding, and disease category. Cumulative density function plots were used to determine whether article placement distribution was different from the expected distribution. Odds ratios for articles published in the first three places of an issue compared with the last three places were calculated. Altmetric score and downloads were meta-analysed.

Results. Article placement order did not associate with author gender, geographical region or funding source, but was associated with disease category. Articles about rheumatoid arthritis were more likely to be ordered at the front of issues ($P<0.001$). Articles about crystal arthritis, systemic lupus erythematosus, vasculitis, pain syndromes and pediatric rheumatic diseases were more likely to be ordered at the end of issues (all $P<0.001$). Association of article placement order with disease category was observed only in journals with tables of contents grouped by disease. Articles ordered in the first three places had higher Altmetric and download rates, than articles in the last three places.

Conclusions. Author gender, geographical region, or funding source do not influence article placement order in serial rheumatology journals. However, bias for certain disease categories is reflected in article placement order. Editorial decisions about article placement order can influence the prominence of diseases.

Keywords: publication, bias, rheumatology

Strengths and limitations of the study

- This is the first study to assess the relationship of article placement order in serial medical journals with author gender, geographical region of affiliated institution, industry funding or disease category.
- This content analysis included 6,787 articles from general rheumatology journals.
- This study also analysed the impact of article placement order on research prominence, including Altmetric scores and download rate.
- This analysis did not explore other factors that may have contributed to article placement order such as the originality of the study findings or the presence of "star" authors.

INTRODUCTION

The strong preference for items ordered first, and the important effect of list order on choice, is well-recognised in consumer-based research.[1-3] In online searches for health information, 97% of selected links were displayed in the first 10 results, while only 2% were from the second or following pages.[4] For online academic repositories, earlier listed articles were downloaded more frequently than later listed articles.[5] These primacy effects, which increase when lists are longer,[6] may occur because earlier items, or those at the top of tables of contents, are more visible and more likely to be seen and read.[5]

In academic publishing, the ordering of articles within a journal issue also affects the prominence achieved by that research. Earlier listed articles received more citations over a 25 year period in a single journal.[7] The impact of ordering was also evident in an analysis of emails sent to subscribers disseminating recent research papers listed in random order; with the first paper having a 33% increase in views, 29% increase in downloads and 27% increase in citations, regardless of research quality.[8]

A number of systemic biases have been reported in academic publishing. These include preferential lead and senior authorship of men,[9, 10] higher acceptance rates for articles from the US and Europe,[9, 11] preferential publication of industry-funded research,[12] and disease privileging, wherein particular diseases receive preferential research funding and publication.[13-15] It is unknown whether these systemic biases are reflected in article placement order within medical journals. We analysed serial rheumatology journals for relationships between article placement order and gender of the lead and senior authors, geographical region of the affiliated institution, industry sponsorship, and disease category.

METHODS

Patient and public involvement

There was no patient or public involvement in the design, or conduct, or reporting, of this research.

Identification of journals and articles for inclusion

This was a cross-sectional content analysis of original articles published in general rheumatology journals. Journals were included if they produced regular issues, reported original research and had 2016 Thomas Reuters Impact Factors of > 3.0. Journals were excluded if they published review articles only, were disease-specific (e.g. *Lupus*, *Osteoarthritis and Cartilage*) or produced no issues. The following seven general rheumatology journals met the above criteria and were included: *Annals of the Rheumatic Diseases, Arthritis & Rheumatology, Arthritis Care & Research, Seminars in Arthritis and Rheumatism, Rheumatology, Journal of Rheumatology*, and *Joint Bone Spine*. Characteristics of the included journals are shown in **Supplementary Table 1**.

All original articles published in the included journals in a five-year period from June 2013 to June 2018 were included in the analysis. To be included, articles could be full or concise reports, and report on original basic science or clinical research, including systematic reviews and meta-analyses. Articles were excluded if they were from a disease-specific thematic issue or supplement, were narrative reviews, recommendations, guidelines, letters, or meeting reports.

Data extraction

Data extraction was undertaken between June and December 2018. The following information was extracted for each included article: order number of article in the issue, gender of lead (first) author; gender of senior (final) author; geographical region of affiliated institution (for the first author); any industry sponsorship (industry-funded and initiated/industry-funded and investigator-initiated/not industry-funded); and, if available, the Altmetric score and number of downloads. The number of citations was not assessed because of the short time period between publication and data extraction. If author gender could not be determined by first name or by an internet search of the author's affiliated institution profile page, then the author's first name was entered into https://api.genderize.io/?name= which returns the gender and probability of certainty. Probabilities < 0.5 were labelled as "unknown" and not included in the gender-related analysis. If articles were authored by a single author, then this author's gender was entered under first author. Funding was assessed by review of funding statements, disclosures and author affiliations. Industry-funded studies were categorized as industry-funded and industry-initiated, or industry-funded and investigator-initiated, based on these statements. Studies with no evidence of industry funding were categorized as not industry-funded.

Articles were coded according to the following 13 disease categories: ankylosing spondylitis and other spondyloarthropathy, crystal arthritis, osteoarthritis, miscellaneous rheumatic disease, pediatric rheumatology, pain syndromes, psoriatic arthritis, rheumatoid arthritis, systemic lupus erythematosus, systemic sclerosis/scleroderma, other connective tissue disorders, vasculitis, and not disease-specific. The title of each article was used to determine the disease category. If there was uncertainty about the disease category from the title, then the abstract and/or full paper were reviewed.

To ensure standardisation in data extraction, two authors (SS, ND) independently reviewed eligible papers from ten randomly selected issues. A total of 208 articles were reviewed, with

kappas of 1.00 for author gender, geographic region and industry funding, while disease category had a kappa of 0.84 (86.1% agreement (95% confidence interval (CI) 81.0%, 90.5%)). All disease category disagreements were discussed to reach a consensus and a set of rules for categorising was established. The exercise was then repeated in which the two authors reviewed disease categories in a further five randomly selected issues totalling 85 articles, with a kappa of 0.99 (98.8% agreement (95% CI 94.3%, 99.9%)) for disease category. A single reviewer (SS) then independently extracted the data.

Data analysis

The primary analyses assessed the relationships between article placement order and: gender of first authors, gender of last authors, geographical region (North America vs. Europe vs. Other), industry funding categories (industry-funded and initiated vs. industry-funded and investigator-initiated vs. not industry-funded), and disease categories. In order to identify whether these factors were associated with article placement order within journal issues, each article within each issue was assigned a standard article placement index (SAPI), which was defined as the order of the article in the issue/total number of articles in the issue. For example, the first article in an issue of 21 articles was given an SAPI of 1/21 = 0.0476 and the last article 21/21 = 1. This metric allowed standardisation of article placement order within issues with the expectation that the number of articles within each issue would vary widely across different journals. For example, the SAPI could scale between article placement in a journal issue of five articles and one with 50 articles. Therefore, this metric addressed the large variation in the number of articles between different journal issues and overcame the potential issue of skewed average article placement order data resulting from issues with large numbers of articles. The SAPI as a placement metric enabled the

examination of article placement order without an assumption that the mean (or median) article placement order was different. Cumulative distribution functions (CDF) of SAPIs were analysed to determine the associations between article placement order and author gender, geographical region industry funding and disease category. A uniform distribution would be expected if there was no association with article placement order: deviations from the expected uniform distribution would support an association with article placement order. To test whether the distribution of SAPIs were different between author genders, geographical regions, and industry funding categories, two-sample Kolmogorov-Smirnov Z tests were conducted. Due to the sensitivity of this test [16], the effect sizes (*D*) were also computed with values ranging from 0 (no difference in distribution of SAPI between comparisons) to 1 (large difference in distribution of SAPI between comparisons) to provide further description of the deviations between the observed distributions. To determine whether the distribution of SAPIs for each disease category was different from a uniform distribution CDF (expected distribution if no bias reflected in article placement order), the area under the curve (AUC) of the observed CDF and uniform distribution CDF were each calculated using a trapezoidal method and the difference between these estimated for each of the 13 disease categories. Mean differences between the observed CDF and the uniform distribution CDF AUCs were computed from bootstrapped samples (500 replicates, sampled with replacement) and 95% confidence intervals estimated as the 2.5th and 97.5th percentile of the bootstrap distribution. P-values were calculated for each disease category from these confidence intervals using the method of Altman and Bland.[17] This analysis method allowed for an assumption-free comparison of the observed and expected distributions of SAPIs.[18] CDF-based comparisons are estimates and do not systematically increase or decrease with sample size. The estimated CDF, like an estimated mean, is unbiased at any sample size. The estimation of the CDF (like estimation of a mean) assumed only that each

variable examined provided some incremental information; that is, that collinearity was not close to perfect.[19] Unlike the comparison of a central tendency statistic (i.e. mean or median order placement), comparing these distributions allowed testing of any early and late article placement (bimodal) clustering (primacy and recency) as well as a uniform distribution of placement. CDF plots of SAPIs also provided a visually clear representation of article placement order and potential differences between groups.

A secondary analysis was undertaken to further explore article placement order, in which mid-P exact P-values were computed to compare the proportion of articles appearing in at least one of the first three places of an issue compared to at least one of the last three places of an issue for genders of first and last authors, geographical region, industry funding category, and each disease category. Odds ratios (OR) and their 95% CIs were also computed for articles in the first three places vs. last three places of an issue.

As some journals presented their content grouped by disease category, additional analyses were undertaken to determine whether article placement order of disease categories was different between journals which presented content grouped by disease category vs. journals without disease category content grouping. This was tested statistically using CDF plots of SAPI distributions, two-sample Kolmogorov Smirnov Z tests and effect sizes (D) as described above.

To further explore factors associated with article placement order, a supplementary *post hoc* analysis was undertaken to compare the median order of an article within an issue between genders, geographical regions, industry funding categories and disease categories using Mann-Whitney U or Kruskal Wallis tests, as appropriate.

Finally, to determine the impact of article placement order on Altmetric scores and article download rates (as available), meta-analyses were used to determine differences in the means for each variable between the first and last three articles in journal issues. Altmetric scores were provided by *Arthritis & Rheumatology, Annals of the Rheumatic Diseases*, *Rheumatology* and *Arthritis Care & Research*. *Annals of the Rheumatic Diseases*, *Rheumatology* and *The Journal of Rheumatology* had article download data available, but for the latter two journals, the data were available in only the 6 months prior to data extraction. Therefore, analyses of article downloads were undertaken for *Annals of the Rheumatic Diseases* only. For Altmetric scores, which generally do not change over time, mean scores were calculated by total Altmetric scores/total number of articles. For downloads, which are time dependent, rates were calculated by total number of downloads/total article-years from time of publication to time of data extraction. These analyses were undertaken within disease categories, adjusted by journal, as appropriate, and weighted using the inverse-variance method. Random effects models were used for all I^2 values > 0%.

All analyses were performed in SPSS (v25 IBM Corp), SAS v9.4 (SAS Institute Inc, Cary, NC) and openepi.com (v3.01). All tests were two-tailed and false discovery rate (FDR)-adjusted *P* values [20] were computed for all analyses with an alpha level of < 0.05 considered significant.

RESULTS

Characteristics of included articles

A total of 6,787 articles were included; 488 (7.2%) were randomised controlled trials, 438 (6.5%) were systematic literature reviews or meta-analyses, 4,466 (65.8%) were other clinical research studies, and 1,395 (20.6%) reported basic research. First authors were male in 3250

(47.9%) articles, female in 3517 (51.8%) articles and unknown in 20 (0.3%) articles. Last authors were male in 4412 (65.0%) articles, female in 2359 (34.8%) articles and unknown/not applicable in 16 (0.2%) articles. 596 (8.8%) articles were industry-funded and initiated, 640 (9.4%) were industry-funded and investigator-initiated, and 5551 (81.8%) were not industry-funded. The geographical region was North America in 2177 (32.1%) articles, Europe in 3486 (51.4%) articles, and Other in 1124 (16.6%) articles. Disease categories were rheumatoid arthritis (n = 1946, 28.7%), osteoarthritis (n = 773, 11.4%), systemic lupus erythematosus (n = 642, 9.5%), ankylosing spondylitis (n = 496, 7.3%), pediatric rheumatology (n = 443, 6.5%), systemic sclerosis (n = 433, 6.4%), not disease-specific (n = 422, 6.2%), vasculitis (n = 362, 5.3%), other connective tissue disease (n = 339, 5.0%), miscellaneous (n = 277, 4.1%), crystal arthritis (n = 269, 4.0%), psoriatic arthritis (n = 242, 3.6%), and pain syndromes (n = 143, 2.1%). The specific diseases which were categorised under crystal arthritis, other connective tissue disease, and miscellaneous are shown in **Supplementary Table 2**.

Distribution of article placement within issues

Inspection of the cumulative distribution function plots showed no association of article placement order with author gender, geographical region, or industry funding (**Figure 1**). However, differences in article placement order were observed for disease category (**Figure 2** and **Table 1**). Articles about rheumatoid arthritis were more likely to be placed towards the front of issues. The placement of articles about ankylosing spondylitis, osteoarthritis and psoriatic arthritis conformed to a uniform distribution. Articles about systemic lupus erythematosus, other connective tissue diseases, crystal arthritis, systemic sclerosis, vasculitis, pediatric rheumatology and pain syndromes were more likely to be placed towards

the back of issues. Analysis of the association between article placement order and research type demonstrated that articles reporting on randomised controlled trials, systematic literature reviews or meta-analyses, and other clinical research were more likely to be placed towards the front of issues compared to basic science research articles, with a significant difference in CDFs (all $P < 0.05$) (**Supplementary Figure 1**).

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Table 1. Difference in distribution of standard article placement indices (SAPI) from a uniform distribution for each disease category

	N (%)	SAPI, mean (SD)	Difference in AUC between CDF and uniform distribution	
			Mean (95% confidence interval)[a]	FDR-adjusted *P*
Ankylosing spondylitis	496 (7.3%)	0.51 (0.24)	+0.001 (-0.022, +0.014)	0.94
Crystal arthritis	269 (4.0%)	0.63 (0.28)	-0.134 (-0.141, -0.110)	**<0.001**
Miscellaneous	277 (4.1%)	0.68 (0.29)	-0.182 (-0.205, -0.150)	**<0.001**
Not disease-specific	422 (6.2%)	0.61 (0.30)	-0.092 (-0.103, -0.069)	**<0.001**
Osteoarthritis	773 (11.4%)	0.49 (0.24)	+0.002 (-0.014, +0.021)	0.88
Other connective tissue diseases	339 (5.0%)	0.62 (0.25)	-0.110 (-0.127, -0.090)	**<0.001**
Pediatric rheumatology	443 (6.5%)	0.69 (0.28)	-0.190 (-0.230, -0.180)	**<0.001**
Pain syndromes	143 (2.1%)	0.69 (0.27)	-0.183 (-0.260, -0.152)	**<0.001**
Psoriatic arthritis	242 (3.6%)	0.53 (0.24)	-0.012 (-0.045, 0.015)	0.55
Rheumatoid arthritis	1946 (28.7%)	0.36 (0.28)	+0.144 (+0.141, +0.157)	**<0.001**
Systemic lupus erythematosus	642 (9.5%)	0.58 (0.21)	-0.073 (-0.087, -0.050)	**<0.001**
Systemic sclerosis	433 (6.4%)	0.64 (0.24)	-0.140 (-0.147, -0.122)	**<0.001**
Vasculitis	362 (5.3%)	0.65 (0.24)	-0.154 (-0.180, -0.122)	**<0.001**

AUC = area under the curve; CDF = cumulative density function; SAPI = standard articles placement index. [a]*Positive differences indicate deviations from a uniform distribution above the uniform distribution function (i.e. article placement towards the front of an issue), while negative differences indicate deviations from a uniform distribution below the uniform distribution function (i.e. article placement towards the back of an issue).*

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Articles in the first and last three places of an issue

There were no significant differences in the proportion of articles in the first vs. last three places of an issue for author gender, geographical regions, or industry funding category (**Supplementary Table 3**). However, consistent with the cumulative distribution function analysis, differences for disease category were observed (**Figure 3 and Supplementary Table 3**). There was a significantly greater proportion of articles in the first three compared to the last three places of an issue for rheumatoid arthritis (35.6% vs. 8.7% $P < 0.001$) with an OR (95% CI) of 5.77 (4.80, 6.92). There was a similar proportion of articles in the first three and last three places of an issue for ankylosing spondylitis, osteoarthritis, or psoriatic arthritis. There was a significantly lower proportion of articles in the first three compared to the last three places of an issue for crystal arthritis (10.8% vs. 26.8%), other connective tissue diseases (6.8% vs., 16.5%), pediatric rheumatology (8.4% vs. 38.8%), pain syndromes (8.4% vs. 37.1%), systemic lupus erythematosus (4.7% vs. 9.7%), systemic sclerosis (4.4% vs. 18.2%) and vasculitis (6.4% vs. 18.0%) (all $P \leq 0.001$). Differences in the proportion of articles in the first vs. last three places of an issue were also observed for research type, with a significantly higher proportion of articles in the first three compared to the last three places of an issue for randomised controlled trials (26.4% vs. 10.9%), systematic literature reviews/meta analyses (24.2% vs. 16.7%) and other clinical research (17.0% vs. 13.6%) (all $P \leq 0.003$) and a significantly lower proportion of articles in the first three compared to last three for basic science research (7.6% vs. 26.2% $P < 0.001$) (**Supplementary Table 3**).

Comparison of median article placement order rank

Post hoc analyses of the differences in median article placement order between genders, geographical regions and industry funding categories and disease categories are shown in

Supplementary Table 4. Significant differences in median article placement order were observed between disease categories, with all categories demonstrating greater median article placement order (indicative of placement towards the back of journal issues) compared to rheumatoid arthritis (all $P < 0.001$).

Journals with and without content grouped by disease category

Arthritis & Rheumatology, *Seminars in Arthritis and Rheumatism*, *Arthritis Care & Research* and *The Journal of Rheumatology* grouped issue content by disease category with disease-specific tables of contents sections, while *Annals of the Rheumatic Diseases*, *Rheumatology*, and *Joint Bone Spine* did not group issue content by disease category (**Supplementary Table 1**). Journals with content grouped by disease showed an association between article placement order and disease category, whereas this was less evident for journals without content grouped by disease (**Figure 4**). Comparisons between journals with and without content grouped by disease category demonstrated a significant difference in the SAPI distributions for every disease category, with articles on rheumatoid arthritis placed towards the front of issues, and articles on crystal arthritis, pain syndromes, pediatric rheumatology, systemic sclerosis and vasculitis placed towards the end of issues, in journals with content grouped by disease category (**Supplementary Table 5**).

The impact of article placement order on Altmetric scores and downloads

The impact of article placement order was evident in the meta-analysis results, which showed a higher Altmetric score (adjusted for journal) for articles published in the first three places of an issue compared with the last three, (mean difference in Altmetric score of 5.11, 95% CI 1.50, 8.71, $Z = 2.78$, $P = 0.005$) (**Figure 5**). The difference in Altmetric scores varied across

different disease categories (I^2 76%; $P < 0.001$), with the largest difference between positioning in the first three places and positioning in the last three places being observed for articles about rheumatoid arthritis and psoriatic arthritis.

Similarly, meta-analysis showed that articles published in the first three places of an issue had a higher download rate compared to articles in the last three places of an issue (pooled rate difference (95% CI) 442.1 (293.0, 591.2) downloads/article year, Z = 5.81, $P < 0.001$) (**Figure 5**). The difference in download rate between the first and last three articles was similar across different disease categories (I^2 24%; $P = 0.21$).

DISCUSSION

In this analysis of serial rheumatology journals, no relationship between article placement order and author gender, geographical region or industry sponsorship was observed. However, differences for disease category were apparent, with more frequent positioning of articles about rheumatoid arthritis towards the front of journal issues, and articles about crystal arthritis, other connective tissue diseases, pediatric rheumatology, pain syndromes, systemic lupus erythematosus, systemic sclerosis and vasculitis towards the back of issues. Analyses of Altmetric scores and download rates suggested that article placement order influences research prominence, with earlier placed articles receiving more attention.

Medical journals are central to evidence-based practice and represent a key source of new knowledge for medical professionals.[21, 22] Unbiased publication practices are important in allowing a variety of perspectives and emphases to expand the scope of research and clinical practice. Although bias has been previously reported in academic journals based on authorship ordering of genders,[9, 10] representation of geographical regions,[9, 11] and acceptance and time to publication based on industry sponsorship,[12] our analysis showed

that these factors were not associated with article placement order within serial rheumatology journals.

Articles about rheumatoid arthritis were preferentially placed towards the front of rheumatology journals, while other conditions, particularly pain syndromes, crystal arthritis, pediatric syndromes, and connective tissue diseases, were ordered towards the back. Rheumatoid arthritis was the disease category with the greatest number of articles, therefore giving it the greatest opportunity to be listed first, but our analyses accounted for the variation in article numbers between disease categories. Although rheumatoid arthritis is a very important rheumatic disease,[23] general rheumatology practice involves the diagnosis and treatment of a wide range of diseases.[24, 25] General rheumatology journals should ideally reflect that diversity of clinical practice. A similar distribution of articles on each disease category would therefore be expected if there was no bias for disease category.

The reason for the observed differences in article placement for disease category is unclear. Disease privileging in other fields of medical research has been reported, with some prevalent diseases with high global impact being under-funded and under-researched.[13-15] Crystal arthritis, osteoarthritis and pain syndromes are common; for example, prevalence estimates for US adults for gout are 3.9%, [26] for osteoarthritis are 13.4%, [27] and for low back pain are 26.4%.[28] However, these conditions may be viewed by rheumatologists and journal editors as less important or less severe.[29, 30] Our analysis of article placement order, which did not reflect prioritising of diseases based on epidemiology or severity, emphasises the disconnect between the prevalence of disease and health research. These perceptions of some rheumatic diseases have the potential to impact attitudes in clinical practice and contribute to lower quality of care.[30, 31] Rheumatic diseases such as vasculitis, pediatric rheumatic disease, and scleroderma are less common, but can lead to major morbidity and reduced quality of life. Improving the impact and accessibility of research published on 'lower

priority' or less common rheumatic diseases may have an important impact on clinicians' understanding about and attitudes towards these conditions in clinical practice.

Differences in article placement order for disease category was particularly evident in journals with disease-specific tables of contents sections within issues, rather than journals that did not group issue content by disease category. It has been suggested that grouping article content by disease category may improve the reader experience.[32] However, such decisions have the potential to further reduce readers' exposure to diseases that are already under-studied or less well understood. Editorial decisions to remove grouping by disease category, or to cycle the order of disease category groups for each issue may be a simple solution to overcome bias for disease category reflected in article placement order.

In our analysis, articles appearing in the first three places of an issue had higher Altmetric scores and download rates compared to articles appearing in the last three places of an issue. This is consistent with prior studies which also demonstrate the impact of the primacy effect on research prominence.[6-8] Collectively, these findings indicate that articles placed at the front of journal issues receive greater prominence. The prominence and impact of research published in journals has an important role in not only providing information to improve knowledge and treatment, but also in financing further research[33] and obtaining academic promotion.[34]

The current analysis has some limitations. Firstly, Altmetric and download data were not available from all journals included in the analysis, and it is unclear whether similar differences are present across all journals. Secondly, citation rates were not evaluated because of the short time period between article publication and data extraction which would not have reflected true citation rates, which increase over time. Finally, this analysis did not explore other factors that may have contributed to article placement order such as quality, impact, or

originality of the study, or the presence of prolific or "star" authors.[35] Further research may also focus on identifying factors influencing editorial decisions about the placement order of articles about different diseases. For example, we did observe that basic science articles were placed towards the back of an issue, suggesting that editors prioritise clinical research over laboratory-based research. A strength of this paper is the use of multiple methods of analysis to explore the relationship between disease category and article placement order, including an analysis of the distribution of article placement, an analysis of the difference in proportion of articles appearing in the first and last three places of an issue, and an analysis of the comparison of median article placement order between disease categories. Collectively, these results provide robust and detailed evidence that bias for certain disease categories is reflected in article placement order.

In conclusion, author gender, geographical region, or funding source do not influence article placement order in serial rheumatology journals. However, bias for certain disease categories is reflected in article placement order. Article placement order may have an impact on research prominence, including Altmetric scores and download rate. Editorial choices about the serial position of articles within journals can influence prioritisation of certain diseases.

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Competing interests

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Author contributions

SS contributed towards acquisition, analysis and interpretation of the data. GG contributed towards design of the study and analysis and interpretation of the data. AG contributed towards design of the study and interpretation of the data. ND contributed towards design of the study, and acquisition and interpretation of the data. All authors were involved in drafting of the work or revising it critically for important intellectual content. All authors approved the final version to be published and agree to be accountable for all aspects of the work.

Data statement

All extracted data used in the analyses are available upon reasonable request from the corresponding author.

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Figure legends

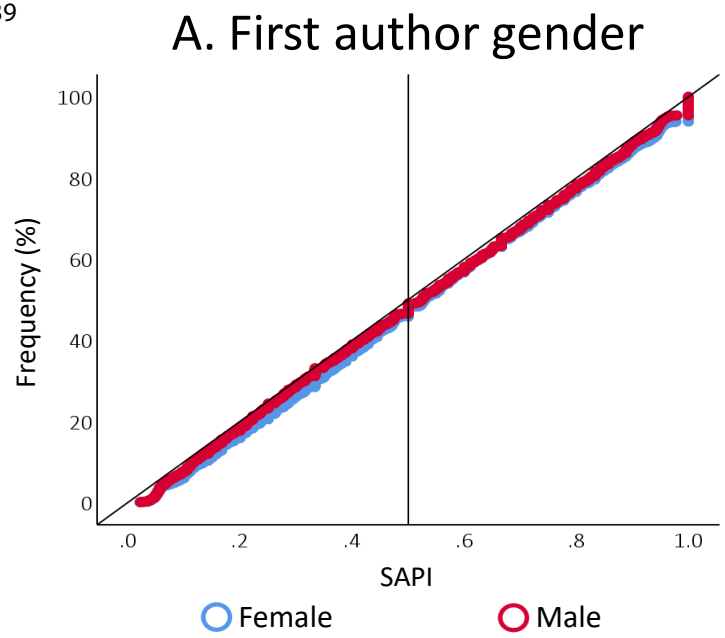
Figure 1. Cumulative distribution function plots of standardised article placement indices (SAPI) for first author gender (**A.**), senior author gender (**B.**), industry funding (**C.**), and first author's geographic region of affiliated institution (**D.**). Left deviated distributions suggest prioritisation towards the front of journal issues.

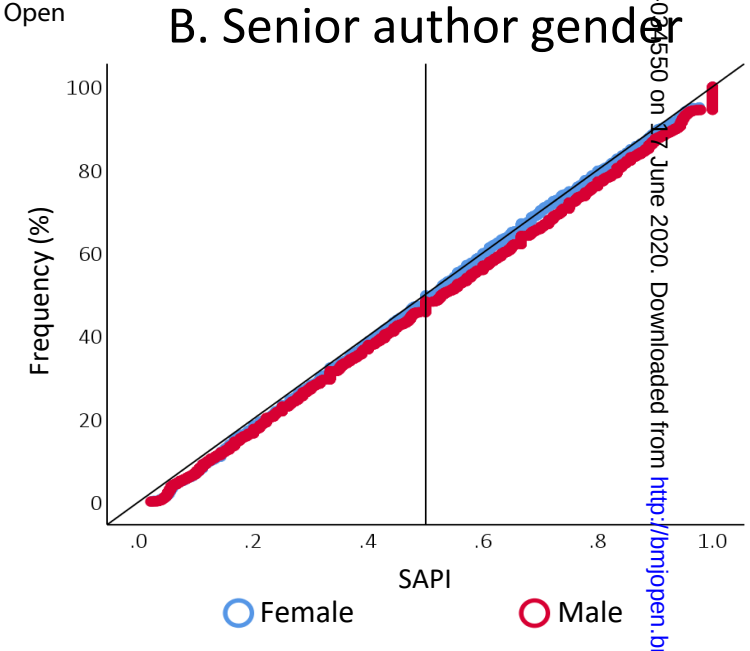
Figure 2. Cumulative distribution function plots of standardised article placement indices (SAPI) for each disease category. Left deviated distributions suggest prioritisation towards the front of journal issues.

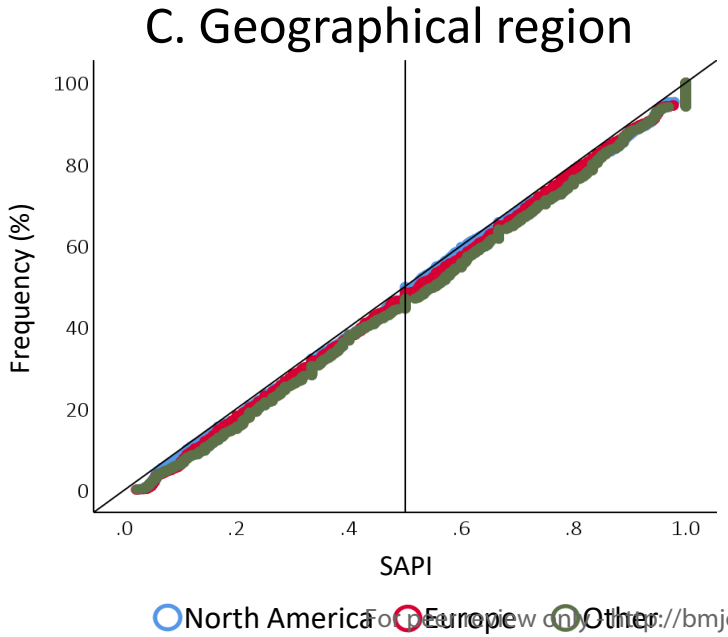
Figure 3. Percentage of articles (per disease category) published in first three and last three places of an issue (*P*-values indicate difference between proportions of articles in first and last three places of an issue).

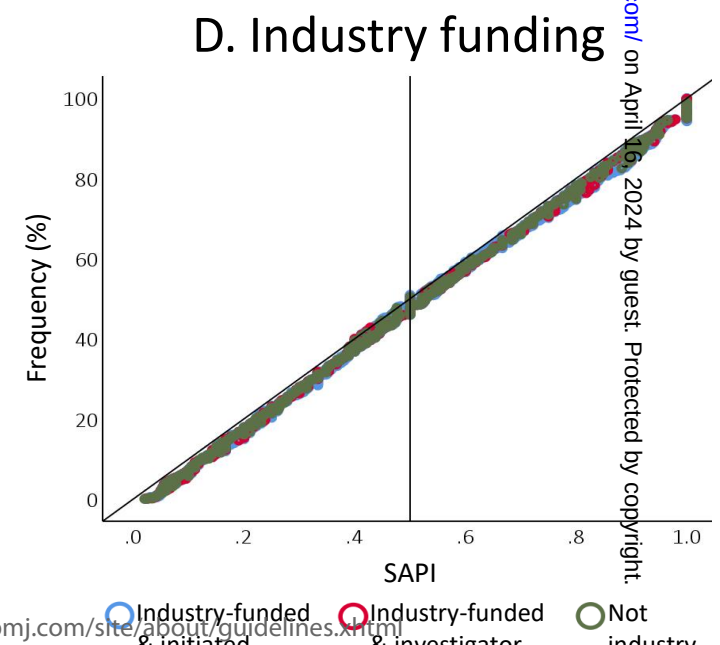
Figure 4. Cumulative distribution function plots of standardised article placement indices (SAPI) for each disease category for journals with (**A.**) and without (**B.**) contents grouped by disease. Left deviated distributions suggest prioritization towards the front of journal issues.

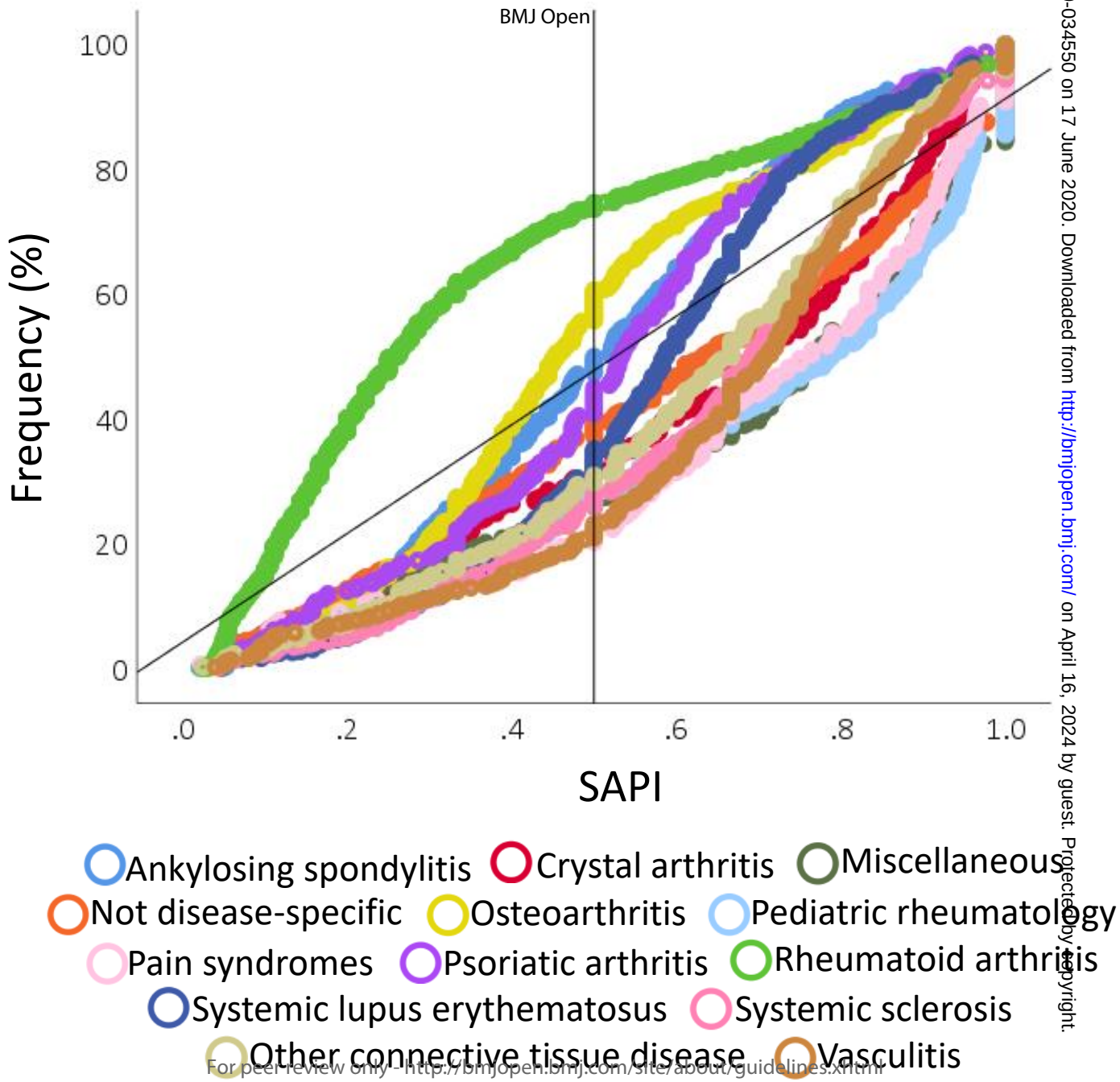
Figure 5. Forest plots showing the mean differences for each disease category for Altmetric scores (**A.**) and download rates (**B.**) between articles published in the first vs. last three places of an issue. Positive differences indicate a higher Altmetric score/download rate for articles published in one of the first three places of an issue. Differences in Altmetric scores are adjusted for journal. Download data was available from one journal. CTD: connective tissue disease.

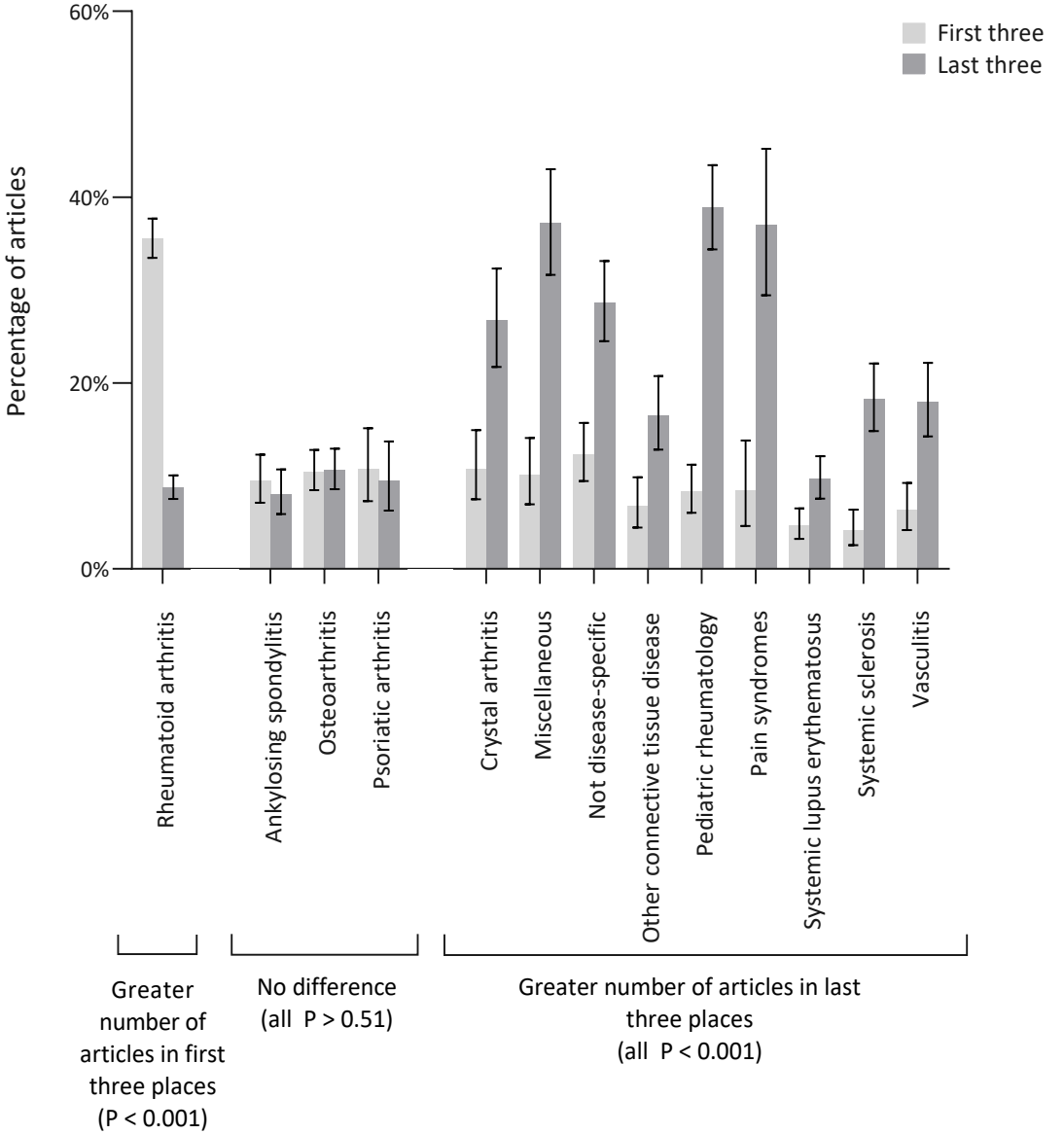




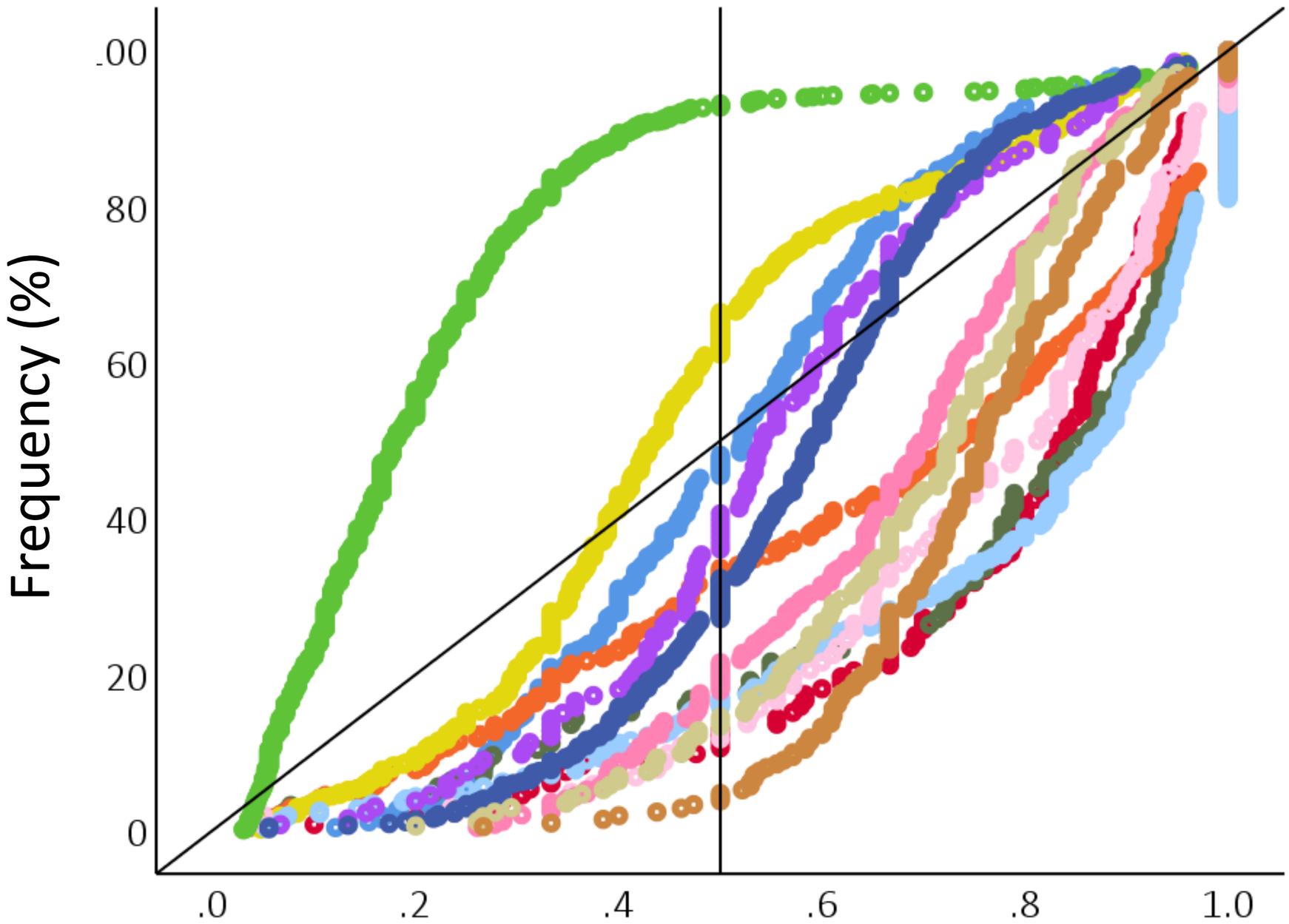




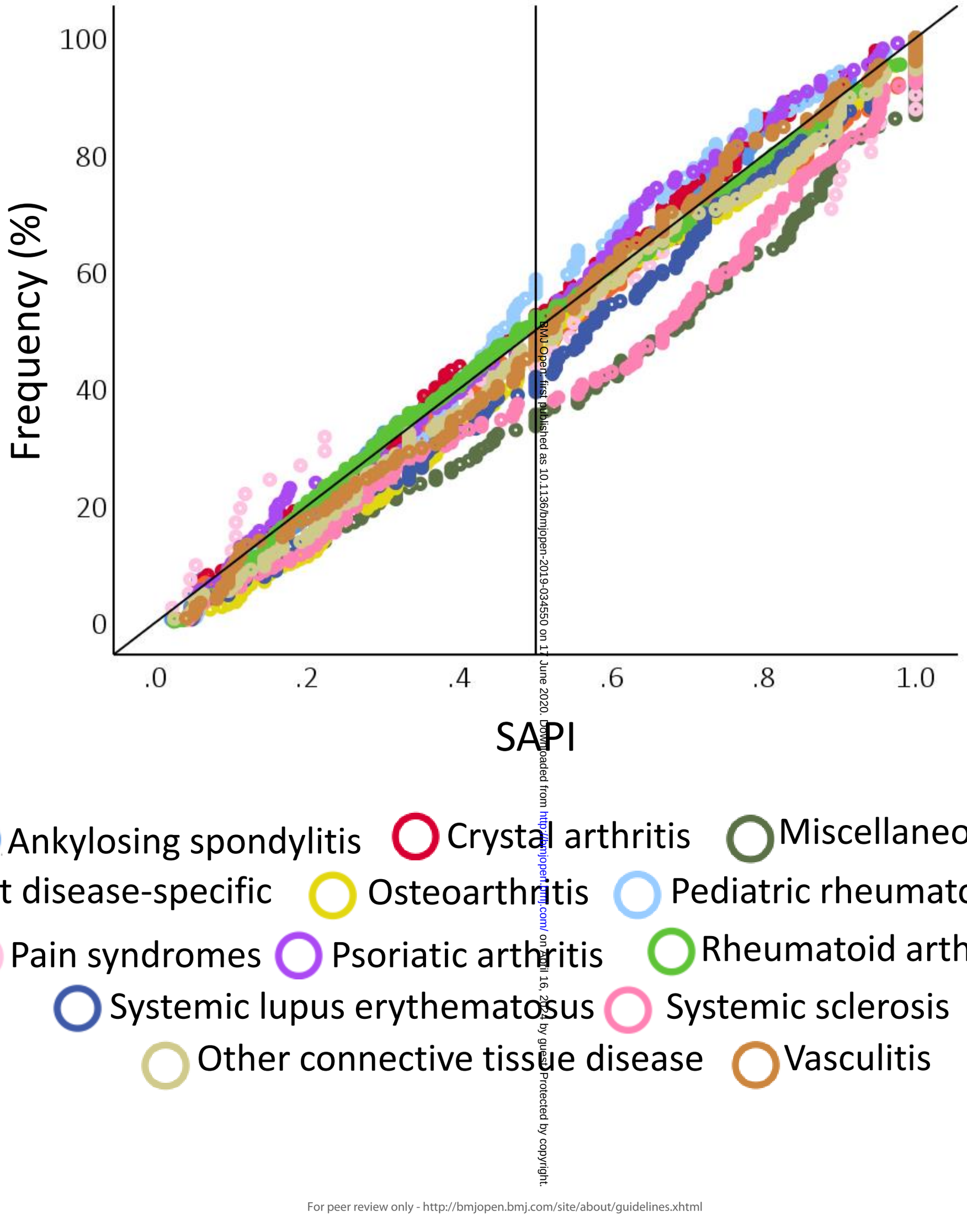




A. Journals with issue content grouped by disease



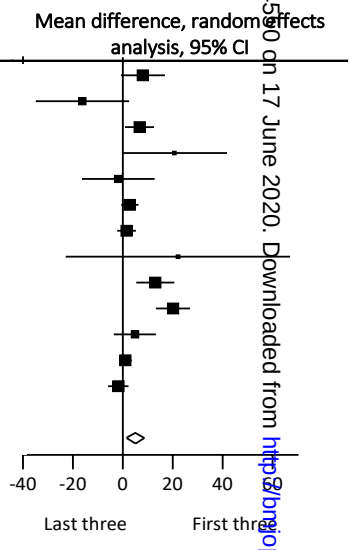
B. Journals without issue content grouped by disease



A. Differences in Altmetric scores between articles in first and last three places of an issue

	First three Mean score	N	Last three Mean score	N	Weight	Score difference	95% CI
Ankylosing spondylitis	14.19	32	6.10	31	7.44%	8.09	(-0.70, 16.88)
Crystal arthritis	9.10	21	25.23	39	2.90%	-16.14	(-34.85, 2.58)
Miscellaneous	10.95	20	4.18	50	9.93%	6.77	(0.99, 12.55)
Not disease-specific	28.47	36	7.73	66	2.40%	20.74	(-0.33, 41.82)
Osteoarthritis	18.47	47	20.26	47	4.20%	-1.79	(-16.35, 12.77)
Other CTDs	6.421	19	3.57	47	11.91%	2.85	(-0.58, 6.27)
Pediatric rheumatology	7.14	29	5.57	86	11.63%	1.57	(-2.21, 5.35)
Pain syndromes	48.36	11	26.10	29	0.61%	22.26	(-22.78, 67.30)
Psoriatic arthritis	13.00	17	3.00	17	8.38%	13.06	(5.46, 20.65)
Rheumatoid arthritis	24.16	434	4.03	156	9.01%	20.13	(13.29, 26.97)
Systemic lupus erythematosus	12.59	27	7.69	58	7.69%	4.90	(-3.55, 13.36)
Systemic sclerosis	3.88	17	2.81	69	12.50%	1.07	(-1.49, 3.63)
Vasculitis	2.68	22	4.41	37	11.42%	-1.72	(-5.77, 2.33)
Total		**732**		**732**	**100.0**	**5.11**	**(1.50, 8.71)**

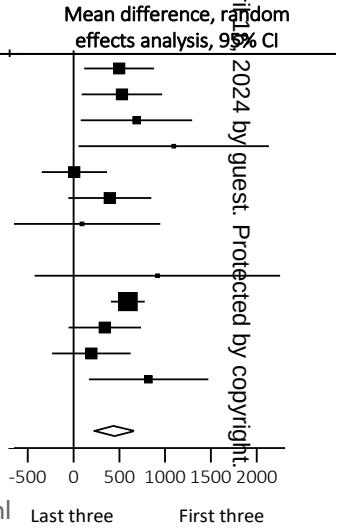
Heterogenity: $Tau^2 = 25.3$; $Chi^2 = 49.8$; $I^2 = 75.9\%$ ($P < 0.001$)
Test for overall effect: Z = 2.78; P = 0.005



B. Differences in download rates between articles in first and last three places of an issue

	First three Mean score	N	Last three Mean score	N	Weight	Rate difference	95% CI
Ankylosing spondylitis	842.8	17	344.9	10	10.9%	497.9	(115.6, 880.3)
Crystal arthritis	726.3	9	198.1	5	8.88%	528.3	(89.2, 967.3)
Miscellaneous	1073.5	7	385.3	12	5.18%	688.1	(78.7, 1297.6)
Not disease-specific	1430.0	15	336.0	15	1.95%	1093.9	(54.7, 2133.1)
Osteoarthritis	465.5	13	457.2	22	12.04%	8.2	(-347.9, 364.4)
Other CTDs	785.3	5	389.1	14	8.40%	396.2	(-58.7, 851.1)
Pediatric rheumatology	758.2	6	626.0	4	3.07%	132.2	(-683.7, 948.1)
Pain syndromes	1110.5	3	346.4	1	0.00%	Excluded	
Psoriatic arthritis	1408.0	14	491.8	3	1.20%	916.2	(-426.3, 2258.7)
Rheumatoid arthritis	952.2	76	358.8	54	24.23%	593.4	(409.2, 777.6)
Systemic lupus erythematosus	880.0	11	538.7	12	10.36%	341.3	(-54.6, 737.2)
Systemic sclerosis	480.6	5	286.8	25	9.19%	193.9	(-235.4, 623.1)
Vasculitis	961.3	3	142.0	6	4.59%	819.3	(165.95, 1472.7)
Total		**183**		**184**	**100.0**	**442.1**	**(293.0, 591.2)**

Heterogeneity: $Tau^2 = 15400$; $Chi^2 = 14.4$; $I^2 = 23.7\%$ ($P = 0.211$)
Test for overall effect: Z = 5.81; P < 0.001



SUPPLEMENTARY MATERIAL

Supplementary Tables

Supplementary Table 1. Journal characteristics

	Publisher	Country of publication	2016 Impact Factor	Relevant affiliated society	Issues per year	Contents grouped by disease	Total number of articles included, n	Number of included articles per issue, mean (SD)
Annals of the Rheumatic Diseases	BMJ Publishing Group Ltd	United Kingdom	12.811	European League Against Rheumatism	12	No	1374	13.2 (9.4)
Arthritis & Rheumatology	John Wiley & Sons	United States	6.918	American College of Rheumatology	12	Yes	1367	12.5 (7.6)
Rheumatology	Oxford University Press	United Kingdom	4.818	British Society for Rheumatology	12	No	1158	10.2 (5.7)
Seminars in Arthritis and Rheumatism	Elsevier	United States	4.498	None	6	Yes	403	7.3 (4.1)
Joint Bone Spine	Elsevier	United States	3.329	French Society of Rheumatology	6	No	239	4.6 (2.6)
Arthritis Care & Research	John Wiley & Sons	United States	3.319	American College of Rheumatology, Association of Rheumatology Health Professionals	12	Yes	1098	9.6 (5.4)
The Journal of Rheumatology	Journal of Rheumatology Publishing Company Limited	Canada	3.150	Canadian Rheumatology Association	12	Yes	1148	10.3 (6.1)

Supplementary Table 2. Number of articles within each disease category for crystal arthritis, miscellaneous and other connective tissue diseases

	Frequency	Percent
Crystal arthritis **(n = 269)**		
Gout	260	96.7
Calcium crystal diseases	9	3.3
Miscellaneous Disease **(n = 277 articles)**		
Regional musculoskeletal syndromes	48	17.3
Osteoporosis	22	7.9
IgG4-related disease	20	7.2
FMF	20	7.2
Polymyalgia rheumatica	19	6.9
CAPS	16	5.8
Still's disease	10	3.6
Septic arthritis	8	2.9
Fibrosis	8	2.9
Sarcoidosis	7	2.5
Chikungunya Virus	7	2.5
SAPHO syndrome	6	2.2
TRAPS	5	1.8
Polychondritis	5	1.8
Ehlers-Danlos Syndrome	4	1.4
Lyme disease	4	1.4
Alkaptonuria	4	1.4
Hemophagocytic syndromes	3	1.1
Vertebral fractures	2	0.7
Uveitis	2	0.7
Undifferentiated arthritis	2	0.7
Tuberculosis	2	0.7
Periodic fever syndrome	2	0.7
Löfgren syndrome	2	0.7
Erdheim-Chester disease	2	0.7
Dupuytren's disease	2	0.7
ACPA-negative undifferentiated arthritis	1	0.4
Yellow fever	1	0.4
Whipple disease	1	0.4
Vertebral endplate lesions	1	0.4
Tumoral calcinosis	1	0.4
Tenosynovial giant cell tumor	1	0.4
Systemic autoinflammatory disease (SAID)	1	0.4
Schnitzler's syndrome	1	0.4
Ribbing disease	1	0.4
Receptor-associated periodic syndrome	1	0.4
Pyogenic sterile arthritis pyoderma gangrenosum and acne (PAPA) syndrome	1	0.4
Pyogenic arthritis	1	0.4
Primary angiitis of the CNS	1	0.4
Preeclampsia	1	0.4
Pigmented villonodular synovitis	1	0.4
Periodic fever, aphthous stomatitis, pharyngitis, and cervical adenitis (PFAPA) syndrome	1	0.4

Paraneoplastic rheumatic syndrome	1	0.4
Palindromic rheumatism	1	0.4
Paget's disease	1	0.4
Osteonecrosis	1	0.4
Osteomyelitis	1	0.4
NOD2-associated autoinflammatory diseases	1	0.4
Muckle-wells syndrome	1	0.4
Mikulicz's disease	1	0.4
Mevalonate kinase deficiency	1	0.4
Medial meniscal tears	1	0.4
Macrophage activation syndrome	1	0.4
Leri's pleonosteosis	1	0.4
Kikuchi-Fujimoto disease	1	0.4
Joint hypermobility syndrome	1	0.4
Immune reconstitution inflammatory syndrome	1	0.4
Hereditary recurrent fever syndromes	1	0.4
Hereditary haemochromatosis	1	0.4
Haploinsufficiency of A20	1	0.4
Glomerulonephritis	1	0.4
Gaucher disease	1	0.4
Femoral fractures	1	0.4
Fabry disease	1	0.4
Ebola virus	1	0.4
Discitis	1	0.4
Chronic graft-versus-host disease	1	0.4
Blau syndrome	1	0.4
Biphosphate trochanteric fracture	1	0.4
Amyloidosis	1	0.4
Aicardi-Goutières syndrome	1	0.4
Other connective tissue disease **(n = 339 articles)**		
Sjogren's syndrome	174	51.3
Inflammatory myositis	115	33.9
Antiphospholipid syndrome	41	12.1
Mixed connective tissue disease	7	2.1
CTD-associated interstitial lung disease	1	0.3
Undifferentiated connective tissue disease	1	0.3

Supplementary Table 3. Number of articles appearing in at least one article in first and last three articles of an issue for author gender, geographical region of affiliated institution, industry funding category, and disease category

	Total articles	First three N	% of total	Last three N	% of total	Odds ratio (OR)[a]	95% CI for OR	*P*[b]
First author gender								
Female	3517	537	15.3%	586	16.7%	0.90	0.79, 1.02	0.17
Male	3250	557	17.1%	509	15.7%	1.11	0.98, 1.27	0.17
Last author gender								
Female	2359	393	16.7%	355	15.0%	1.13	0.97, 1.32	0.17
Male	4412	705	16.0%	737	16.7%	0.95	0.85, 1.01	0.37
Geographical region of affiliated institution (first author)								
North America	2177	362	16.6%	352	16.2%	1.03	0.88, 1.21	0.68
Europe	3486	573	16.4%	556	16.0%	1.04	0.91, 1.18	0.68
Other	1124	163	14.5%	190	16.9%	0.83	0.66, 1.05	0.35
Industry funding								
Industry-funded and initiated	640	104	16.3%	109	17.0%	0.95	0.70, 1.27	0.71
Industry-funded and investigator-initiated	596	87	14.6%	111	18.6%	0.75	0.55, 1.01	0.09
Not industry-funded	5551	907	16.3%	878	15.8%	1.04	0.94, 1.15	0.09
Research type								
Randomised controlled trials	488	129	26.4%	53	10.9%	2.95	2.08, 4.18	**<0.001**
Systematic literature reviews / meta-analyses	438	106	24.2%	73	16.7%	1.60	1.14, 2.23	**0.003**
Other clinical research	4466	757	17.0%	606	13.6%	1.30	1.16, 1.46	**<0.001**
Basic science	1395	106	7.6%	366	26.2%	0.23	0.18, 0.29	**<0.001**
Disease category								
Ankylosing spondylitis	496	47	9.5%	40	8.1%	1.19	0.77, 1.86	0.51
Crystal arthritis[c]	269	29	10.8%	72	26.8%	0.33	0.21, 0.53	**<0.001**
Miscellaneous	277	28	10.1%	103	37.2%	0.19	0.12, 0.30	**<0.001**
Not disease-specific	422	52	12.3%	121	28.7%	0.35	0.24, 0.50	**<0.001**
Osteoarthritis	773	81	10.5%	82	10.6%	0.99	0.71, 1.37	0.934
Other connective tissue diseases	339	23	6.8%	56	16.5%	0.37	0.22, 0.61	**<0.001**
Pediatric rheumatology	443	37	8.4%	172	38.8%	0.14	0.10, 0.21	**<0.001**
Pain syndromes	143	12	8.4%	53	37.1%	0.16	0.08, 0.31	**<0.001**
Psoriatic arthritis[c]	242	26	10.7%	23	9.5%	1.15	0.63, 2.07	0.71
Rheumatoid arthritis	1946	692	35.6%	170	8.7%	5.77	4.80, 6.92	**<0.001**
Systemic lupus erythematosus	642	30	4.7%	62	9.7%	0.46	0.29, 0.72	**0.001**
Systemic sclerosis	433	18	4.4%	79	18.2%	0.19	0.11, 0.33	**<0.001**
Vasculitis	362	23	6.4%	65	18.0%	0.31	0.19, 0.51	**<0.001**

[a]The odds of being in at least one article in the first three places of an issue; [b]FDR-adjusted Mid-P exact P-value. Bolded values indicate significance at < 0.05. [c]One article in each of 'Crystal arthritis' and 'Psoriatic arthritis' came from issues which included 5 articles and were therefore counted in both the 'first' and 'last' three categories.

Supplementary Table 4. Comparison of median article placement order between genders of first and last authors, geographical regions, industry funding categories and disease categories.

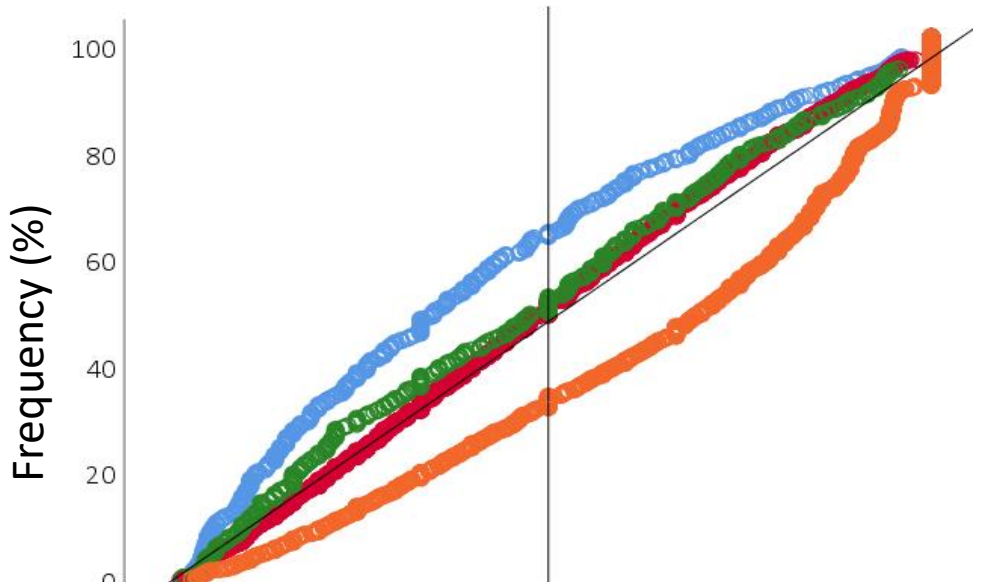
	Article placement order Median (IQR)	Min-max	*P* for difference in medians[a]	
First author gender				
Female	10 (10)	1-45	0.643	
Male	10 (10)	1-49		
Last author gender				
Female	10 (10)	1-46	**0.017**	
Male	10 (10)	1-49		
Geographical region				
North America	10 (10)	1-48	0.906	
Europe	10 (10)	1-49		
Other	10 (10)	1-47		
Industry funding				
Not industry funded	10 (10)	1-48	**<0.001**	
Industry funded and initiated	8 (10)	1-48		
Industry funded and investigator initiated	8 (9)	1-42		
Disease category				***P* for comparison with rheumatoid arthritis[b]**
Ankylosing spondylitis	9 (7)	1-40		<0.001
Crystal arthritis	12 (10)	1-38		<0.001
Miscellaneous	13 (10)	1-49		<0.001
Not disease-specific	11 (10)	1-43		<0.001
Osteoarthritis	10 (8)	1-42		<0.001
Other connective tissue diseases	12 (9)	1-47		<0.001
Paediatric rheumatology	14 (11)	1-35	**<0.001**	<0.001
Pain syndromes	13 (9)	1-32		<0.001
Psoriatic arthritis	10 (7)	1-45		<0.001
Rheumatoid arthritis	5 (8)	1-48		<0.001
Systemic lupus erythematosus	12 (7)	1-41		<0.001
Systemic sclerosis	13 (9)	1-45		<0.001
Vasculitis	13 (9)	1-39		<0.001

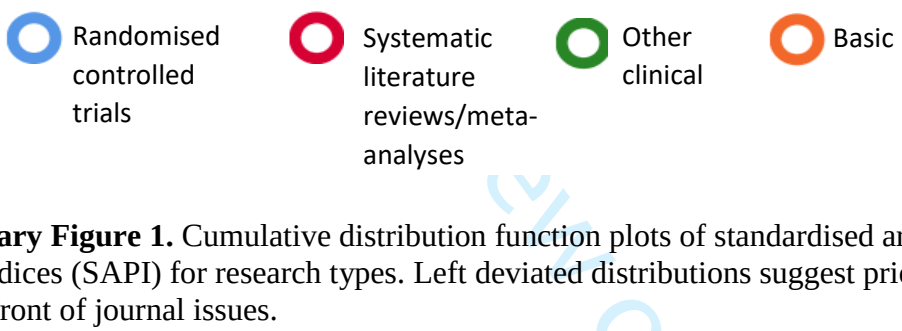
[a]Kruskal Wallis or Mann-Whitney U tests, as appropriate; [b]Mann-Whitney U tests

Supplementary Table 5. Difference in cumulative density function distribution of standard article placement indices (SAPI) between journals with and without contents grouped by disease for articles with related editorials and for each disease category

	Journals with contents not grouped by disease			Journals with contents grouped by disease			Two-sample Kolmogorov-Smirnov Z test[b]	
	N (%)	SAPI[a]		N (%)	SAPI[a]		Effect size (D)	FDR-adjusted P
		Mean	SD		Mean	SD		
Ankylosing spondylitis	228 (8.2%)	0.49	0.28	268 (6.7%)	0.52	0.19	0.20	**<0.001**
Crystal arthritis	137 (4.9%)	0.49	0.28	132 (3.3%)	0.78	0.20	0.50	**<0.001**
Miscellaneous	152 (5.5%)	0.62	0.30	125 (3.1%)	0.76	0.26	0.29	**<0.001**
Not disease-specific	178 (6.4%)	0.53	0.30	244 (6.1%)	0.66	0.29	0.22	**<0.001**
Osteoarthritis	231 (8.3%)	0.55	0.27	542 (13.5%)	0.47	0.22	0.20	**<0.001**
Other connective tissue diseases	167 (6.0%)	0.49	0.29	172 (4.3%)	0.70	0.17	0.36	**<0.001**
Pediatric rheumatology	121 (4.4%)	0.48	0.26	322 (8.0%)	0.77	0.25	0.50	**<0.001**
Pain syndromes	41 (1.5%)	0.54	0.35	102 (2.5%)	0.75	0.21	0.36	**0.001**
Psoriatic arthritis	109 (3.9%)	0.48	0.27	133 (3.3%)	0.56	0.20	0.22	**0.005**
Rheumatoid arthritis	881 (31.8%)	0.51	0.29	1065 (26.5%)	0.23	0.20	0.49	**<0.001**
Systemic lupus erythematosus	193 (7.0%)	0.56	0.28	449 (11.2%)	0.58	0.17	0.19	**<0.001**
Systemic sclerosis	182 (6.6%)	0.60	0.30	251 (6.3%)	0.68	0.18	0.26	**<0.001**
Vasculitis	151 (5.4%)	0.51	0.28	211 (5.3%)	0.75	0.14	0.50	**<0.001**

[a]Lower SAPI scores equate to articles ordered at the front of issues, while higher SAPI scores equate to articles ordered at the end of issues. [b]Test of difference in distribution of SAPI between journals with and without contents grouped by disease sections. Bolded P-values indicated significant difference at < 0.05.





Supplementary Figure 1. Cumulative distribution function plots of standardised article placement indices (SAPI) for research types. Left deviated distributions suggest prioritisation towards the front of journal issues.

BMJ Open

Article Placement Order in Rheumatology Journals: A Content Analysis

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-034550.R2
Article Type:	Original research
Date Submitted by the Author:	25-Feb-2020
Complete List of Authors:	Stewart, Sarah; The University of Auckland, Medicine Gamble, Greg; University of Auckland, Department of Medicine Grey, Andrew; University of Auckland Dalbeth, Nicola; University of Auckland,
Primary Subject Heading:	Rheumatology
Secondary Subject Heading:	Evidence based practice
Keywords:	publication, bias, RHEUMATOLOGY

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Article Placement Order in Rheumatology Journals: A Content Analysis

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Abstract

Objectives. To analyse variables associated with article placement order in serial rheumatology journals.

Design. Content analysis.

Setting. Original articles published in seven rheumatology journals from 2013-2018.

Primary and secondary outcome measures. The following data were extracted from 6,787 articles: order number of article in issue, gender of first and last author, geographical region, industry funding, research design, and disease category. Cumulative density function plots were used to determine whether article placement distribution was different from the expected distribution. Odds ratios for articles published in the first three places of an issue compared with the last three places were calculated. Altmetric score and downloads were meta-analysed.

Results. Article placement order did not associate with author gender or geographical region but was associated with funding source and research design. In addition, articles about rheumatoid arthritis were more likely to be ordered at the front of issues (P<0.001). Articles about crystal arthritis, systemic lupus erythematosus, vasculitis, pain syndromes and pediatric rheumatic diseases were more likely to be ordered at the end of issues (all P<0.001). Association of article placement order with disease category was observed only in journals with tables of contents grouped by disease. Articles ordered in the first three places had higher Altmetric and download rates, than articles in the last three places.

Conclusions. Author gender and geographical region do not influence article placement order in serial rheumatology journals. However, bias for certain disease categories is reflected in article placement order. Editorial decisions about article placement order can influence the prominence of diseases.

Keywords: publication, bias, rheumatology

Strengths and limitations of the study

- This is the first study to assess the relationship of article placement order in serial medical journals with author gender, geographical region of affiliated institution, industry funding, research design or disease category.
- This content analysis included 6,787 articles from general rheumatology journals.
- This study also analysed the impact of article placement order on research prominence, including Altmetric scores and download rate.
- This analysis did not explore other factors that may have contributed to article placement order such as the originality of the study findings or the presence of "star" authors.

INTRODUCTION

The strong preference for items ordered first, and the important effect of list order on choice, is well-recognised in consumer-based research.[1-3] In online searches for health information, 97% of selected links were displayed in the first 10 results, while only 2% were from the second or following pages.[4] For online academic repositories, earlier listed articles were downloaded more frequently than later listed articles.[5] These primacy effects, which increase when lists are longer,[6] may occur because earlier items, or those at the top of tables of contents, are more visible and more likely to be seen and read.[5]

In academic publishing, the ordering of articles within a journal issue also affects the prominence achieved by that research. Earlier listed articles received more citations over a 25 year period in a single journal.[7] The impact of ordering was also evident in an analysis of emails sent to subscribers disseminating recent research papers listed in random order; with the first paper having a 33% increase in views, 29% increase in downloads and 27% increase in citations, regardless of research quality.[8]

A number of systemic biases have been reported in academic publishing. These include preferential lead and senior authorship of men,[9, 10] higher acceptance rates for articles from the US and Europe,[9, 11] preferential publication of industry-funded research,[12] and disease privileging, wherein particular diseases receive preferential research funding and publication.[13-15] It is unknown whether these systemic biases are reflected in article placement order within medical journals. We analysed serial rheumatology journals for relationships between article placement order and gender of the lead and senior authors, geographical region of the affiliated institution, industry sponsorship, and disease category.

METHODS

Patient and public involvement

There was no patient or public involvement in the design, or conduct, or reporting, of this research.

Identification of journals and articles for inclusion

This was a cross-sectional content analysis of original articles published in general rheumatology journals. Journals were included if they produced regular issues, reported original research and had 2016 Thomas Reuters Impact Factors of > 3.0. Journals were excluded if they published review articles only, were disease-specific (e.g. *Lupus*, *Osteoarthritis and Cartilage*) or produced no issues. The following seven general rheumatology journals met the above criteria and were included: *Annals of the Rheumatic Diseases, Arthritis & Rheumatology, Arthritis Care & Research, Seminars in Arthritis and Rheumatism, Rheumatology, Journal of Rheumatology*, and *Joint Bone Spine*. Characteristics of the included journals are shown in **Supplementary Table 1**.

All original articles published in the included journals in a five-year period from June 2013 to June 2018 were included in the analysis. To be included, articles could be full or concise reports, and report on original basic science or clinical research, including systematic reviews and meta-analyses. Articles were excluded if they were from a disease-specific thematic issue or supplement, were narrative reviews, recommendations, guidelines, letters, or meeting reports.

Data extraction

Data extraction was undertaken between June and December 2018. The following information was extracted for each included article: order number of article in the issue, gender of lead (first) author; gender of senior (final) author; geographical region of affiliated institution (for the first author); industry funding category (industry-funded and initiated, industry-funded and investigator-initiated, not industry-funded); research design (basic science, other clinical, randomised controlled trial, systematic literature/meta-analysis); and, if available, the Altmetric score and number of downloads. The number of citations was not assessed because of the short time period between publication and data extraction. If author gender could not be determined by first name or by an internet search of the author's affiliated institution profile page, then the author's first name was entered into https://api.genderize.io/?name= which returns the gender and probability of certainty. Probabilities < 0.5 were labelled as "unknown" and not included in the gender-related analysis. If articles were authored by a single author, then this author's gender was entered under first author. Funding was assessed by review of funding statements, disclosures and author affiliations. Industry-funded studies were categorized as industry-funded and industry-initiated, or industry-funded and investigator-initiated, based on these statements. Studies with no evidence of industry funding were categorized as not industry-funded.

Articles were coded according to the following 13 disease categories: ankylosing spondylitis and other spondyloarthropathy, crystal arthritis, osteoarthritis, miscellaneous rheumatic disease, pediatric rheumatology, pain syndromes, psoriatic arthritis, rheumatoid arthritis, systemic lupus erythematosus, systemic sclerosis/scleroderma, other connective tissue disorders, vasculitis, and not disease-specific. The title of each article was used to determine the disease category. If there was uncertainty about the disease category from the title, then the abstract and/or full paper were reviewed.

To ensure standardisation in data extraction, two authors (SS, ND) independently reviewed eligible papers from ten randomly selected issues. A total of 208 articles were reviewed, with kappas of 1.00 for author gender, geographical region, and industry funding category, while disease category had a kappa of 0.84 (86.1% agreement (95% confidence interval (CI) 81.0%, 90.5%)). All disease category disagreements were discussed to reach a consensus and a set of rules for categorising was established. The exercise was then repeated in which the two authors reviewed disease categories in a further five randomly selected issues totalling 85 articles, with a kappa of 0.99 (98.8% agreement (95% CI 94.3%, 99.9%)) for disease category. A single reviewer (SS) then independently extracted the data.

Data analysis

The primary analyses assessed the relationships between article placement order and: gender of first authors, gender of last authors, geographical region (Europe, North America, Other), industry funding categories (industry-funded and initiated, industry-funded and investigator-initiated, not industry-funded), research design (basic science, other clinical research, randomised controlled trial, systematic literature review/meta-analysis) and disease categories. In order to identify whether these factors were associated with article placement order within journal issues, each article within each issue was assigned a standard article placement index (SAPI), which was defined as the order of the article in the issue/total number of articles in the issue. For example, the first article in an issue of 21 articles was given an SAPI of 1/21 = 0.0476 and the last article 21/21 = 1. This metric allowed standardisation of article placement order within issues with the expectation that the number of articles within each issue would vary widely across different journals. For example, the SAPI could scale between article placement in a journal issue of five articles and one with 50

articles. Therefore, this metric addressed the large variation in the number of articles between different journal issues and overcame the potential issue of skewed average article placement order data resulting from issues with large numbers of articles. The SAPI as a placement metric enabled the examination of article placement order without an assumption that the mean (or median) article placement order was different. Cumulative distribution functions (CDF) of SAPIs were analysed to determine the associations between article placement order and author gender, geographical region, industry funding and disease category. A uniform distribution would be expected if there was no association with article placement order: deviations from the expected uniform distribution would support an association with article placement order. Due to the potential over-sensitivity of this test, [16] the effect sizes (*D*) were also computed with values ranging from 0 (no difference in distribution of SAPI between comparisons) to 1 (large difference in distribution of SAPI between comparisons) to provide further description of the deviations between the observed distributions. To determine whether the distribution of SAPIs for variable was different from a uniform distribution CDF (expected distribution if no bias reflected in article placement order), the area under the curve (AUC) of the observed CDF and uniform distribution CDF were each calculated using a trapezoidal method and the difference between these estimated for each of the variable categories. Mean differences between the observed CDF and the uniform distribution CDF AUCs were computed from bootstrapped samples (500 replicates, sampled with replacement) and 95% confidence intervals estimated as the 2.5th and 97.5th percentile of the bootstrap distribution. P-values were calculated for each category from these confidence intervals using the method of Altman and Bland.[17] This analysis method allowed for an assumption-free comparison of the observed and expected distributions of SAPIs.[18] CDF-based comparisons are estimates and do not systematically increase or decrease with sample size. The estimated CDF, like an estimated mean, is unbiased at any sample size. The

estimation of the CDF (like estimation of a mean) assumed only that each variable examined provided some incremental information; that is, that collinearity was not close to perfect.[19] Unlike the comparison of a central tendency statistic (i.e. mean or median order placement), comparing these distributions allowed testing of any early and late article placement (bimodal) clustering (primacy and recency) as well as a uniform distribution of placement. CDF plots of SAPIs also provided a visually clear representation of article placement order and potential differences between groups.

A secondary analysis was undertaken to further explore article placement order, in which mid-P exact P-values were computed to compare the proportion of articles appearing in at least one of the first three places of an issue compared to at least one of the last three places of an issue for genders of first and last authors, geographical region, industry funding category, and each disease category. Odds ratios (OR) and their 95% CIs were also computed for articles in the first three places vs. last three places of an issue.

As some journals presented their content grouped by disease category, additional analyses were undertaken to determine whether article placement order of disease categories was different between journals which presented content grouped by disease category vs. journals without disease category content grouping. This was tested statistically using CDF plots of SAPI distributions, two-sample Kolmogorov Smirnov Z tests and effect sizes (KS D) as described above.

To further explore factors associated with article placement order, a supplementary *post hoc* analysis was undertaken to compare the median SAPIs between genders, geographical regions, industry funding categories and disease categories using Mann-Whitney U or Kruskal Wallis tests, as appropriate. Mann-Whitney U tests were also undertaken to determine whether article placement order for articles about rheumatoid arthritis differed

from other disease categories. Cohen's *d* were computed for each comparison as measures of effect size with scores of 0.2 considered small, 0.5 considered median and 0.8 considered large [20].

Finally, to determine the impact of article placement order on Altmetric scores and article download rates (as available), meta-analyses were used to determine differences in the means for each variable between the first and last three articles in journal issues. Altmetric scores were provided by *Arthritis & Rheumatology, Annals of the Rheumatic Diseases*, *Rheumatology* and *Arthritis Care & Research*. *Annals of the Rheumatic Diseases*, *Rheumatology* and *The Journal of Rheumatology* had article download data available, but for the latter two journals, the data were available in only the 6 months prior to data extraction. Therefore, analyses of article downloads were undertaken for *Annals of the Rheumatic Diseases* only. For Altmetric scores, which generally do not change over time, mean scores were calculated by total Altmetric scores/total number of articles. For downloads, which are time dependent, rates were calculated by total number of downloads/total article-years from time of publication to time of data extraction. These analyses were undertaken within disease categories, adjusted by journal, as appropriate, and weighted using the inverse-variance method. Random effects models were used.

All analyses were performed in SPSS (v25 IBM Corp) and SAS v9.4 (SAS Institute Inc, Cary, NC). All tests were two-tailed and false discovery rate (FDR)-adjusted *P* values [21] were computed for all analyses with an alpha level of < 0.05 considered significant.

RESULTS

Characteristics of included articles

First authors were male in 3250 (47.9%) articles, female in 3517 (51.8%) articles and unknown in 20 (0.3%) articles. Last authors were male in 4412 (65.0%) articles, female in 2359 (34.8%) articles and unknown/not applicable in 16 (0.2%) articles. The geographical region was Europe in 3486 (51.4%) articles, North America in 2177 (32.1%) articles, and Other in 1124 (16.6%) articles. 596 (8.8%) articles were industry-funded and initiated, 640 (9.4%) were industry-funded and investigator-initiated, and 5551 (81.8%) were not industry-funded. Of the included papers, 1,395 (20.6%) reported basic research, 4466 (65.8%) were categorised as other clinical research studies, 488 (7.2%) were randomised controlled trials and 438 (6.5%) were systematic literature reviews or meta-analyses. Disease categories were rheumatoid arthritis (n = 1946, 28.7%), osteoarthritis (n = 773, 11.4%), systemic lupus erythematosus (n = 642, 9.5%), ankylosing spondylitis (n = 496, 7.3%), pediatric rheumatology (n = 443, 6.5%), systemic sclerosis (n = 433, 6.4%), not disease-specific (n = 422, 6.2%), vasculitis (n = 362, 5.3%), other connective tissue disease (n = 339, 5.0%), miscellaneous (n = 277, 4.1%), crystal arthritis (n = 269, 4.0%), psoriatic arthritis (n = 242, 3.6%), and pain syndromes (n = 143, 2.1%). The specific diseases which were categorised under crystal arthritis, other connective tissue disease, and miscellaneous are shown in **Supplementary Table 2**.

Distribution of article placement within issues

Inspection of the cumulative distribution function plots showed no association of article placement order with author gender or geographical region. However, differences in article placement order were observed for funding source, research design and disease category

(**Figure 1, Supplementary Table 3**). Industry-funded and initiated studies and industry-funded and investigator-initiated studies were more likely to be placed towards the front of journal issues. Similarly, randomised controlled trials were placed towards the front of issues, while basic science research articles were placed towards the back of issues. **Figure 2** and **Table 1** display the differences in article placement order for disease category. Articles about rheumatoid arthritis were more likely to be placed towards the front of issues. The placement of articles about ankylosing spondylitis, osteoarthritis and psoriatic arthritis conformed to a uniform distribution. Articles about systemic lupus erythematosus, other connective tissue diseases, crystal arthritis, systemic sclerosis, vasculitis, pediatric rheumatology and pain syndromes were more likely to be placed towards the back of issues.

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Table 1. Difference in distribution of standard article placement indices (SAPI) from a uniform distribution for each disease category

	N (%)	SAPI, mean (SD)	Difference in AUC between CDF and uniform distribution Mean (95% confidence interval)[a]	FDR-adjusted *P*	Effect size (KS D)[b]
Ankylosing spondylitis	496 (7.3%)	0.51 (0.24)	+0.00 (-0.02, +0.01)	0.94	0.10
Crystal arthritis	269 (4.0%)	0.63 (0.28)	-0.13 (-0.14, -0.11)	<0.001	0.21
Miscellaneous	277 (4.1%)	0.68 (0.29)	-0.18 (-0.20, -0.15)	<0.001	0.30
Not disease-specific	422 (6.2%)	0.61 (0.30)	-0.09 (-0.10, -0.07)	<0.001	0.15
Osteoarthritis	773 (11.4%)	0.49 (0.24)	+0.00 (-0.01, +0.02)	0.88	0.14
Other connective tissue diseases	339 (5.0%)	0.62 (0.25)	-0.11 (-0.13, -0.09)	<0.001	0.20
Pediatric rheumatology	443 (6.5%)	0.69 (0.28)	-0.19 (-0.23, -0.18)	<0.001	0.29
Pain syndromes	143 (2.1%)	0.69 (0.27)	-0.18 (-0.26, -0.15)	<0.001	0.30
Psoriatic arthritis	242 (3.6%)	0.53 (0.24)	-0.01 (-0.04, 0.02)	0.55	0.10
Rheumatoid arthritis	1946 (28.7%)	0.36 (0.28)	+0.14 (+0.14, +0.16)	<0.001	0.30
Systemic lupus erythematosus	642 (9.5%)	0.58 (0.21)	-0.07 (-0.09, -0.05)	<0.001	0.18
Systemic sclerosis	433 (6.4%)	0.64 (0.24)	-0.14 (-0.15, -0.12)	<0.001	0.23
Vasculitis	362 (5.3%)	0.65 (0.24)	-0.15 (-0.18, -0.12)	<0.001	0.27

AUC = area under the curve; CDF = cumulative density function; SAPI = standard articles placement index. [a]*Positive differences indicate deviations from a uniform distribution above the uniform distribution function (i.e. article placement towards the front of an issue), while negative differences indicate deviations from a uniform distribution below the uniform distribution function (i.e. article placement towards the back of an issue).*[b]*From one-sample Kolmogorov-Smirnov Z test.*

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Articles in the first and last three places of an issue

There were no significant differences in the proportion of articles in the first vs. last three places of an issue for author gender, geographical regions, or industry funding category (**Supplementary Table 4**). However, consistent with the cumulative distribution function analysis, differences for disease category were observed (**Figure 3, Supplementary Table 4**). There was a significantly greater proportion of articles in the first three compared to the last three places of an issue for rheumatoid arthritis (35.6% vs. 8.7% $P < 0.001$) with an OR (95% CI) of 5.77 (4.80, 6.92). There was a similar proportion of articles in the first three and last three places of an issue for ankylosing spondylitis, osteoarthritis, or psoriatic arthritis. There was a significantly lower proportion of articles in the first three compared to the last three places of an issue for crystal arthritis (10.8% vs. 26.8%), other connective tissue diseases (6.8% vs., 16.5%), pediatric rheumatology (8.4% vs. 38.8%), pain syndromes (8.4% vs. 37.1%), systemic lupus erythematosus (4.7% vs. 9.7%), systemic sclerosis (4.4% vs. 18.2%) and vasculitis (6.4% vs. 18.0%) (all $P \leq 0.001$). Differences in the proportion of articles in the first vs. last three places of an issue were also observed for research type, with a significantly higher proportion of articles in the first three compared to the last three places of an issue for other clinical research (17.0% vs. 13.6%), randomised controlled trials (26.4% vs. 10.9%), and systematic literature reviews/meta analyses (24.2% vs. 16.7%) (all $P \leq 0.003$) and a significantly lower proportion of articles in the first three compared to last three for basic science research (7.6% vs. 26.2% $P < 0.001$) (**Supplementary Table 4**).

Journals with and without content grouped by disease category

Arthritis & Rheumatology, *Seminars in Arthritis and Rheumatism*, *Arthritis Care & Research* and *The Journal of Rheumatology* grouped issue content by disease category with disease-

specific tables of contents sections, while *Annals of the Rheumatic Diseases*, *Rheumatology*, and *Joint Bone Spine* did not group issue content by disease category (**Supplementary Table 1**). Journals with content grouped by disease showed an association between article placement order and disease category, whereas this was less evident for journals without content grouped by disease (**Figure 4**). Comparisons between journals with and without content grouped by disease category demonstrated a significant difference in the SAPI distributions for every disease category, with articles on rheumatoid arthritis placed towards the front of issues, and articles on crystal arthritis, pain syndromes, pediatric rheumatology, systemic sclerosis and vasculitis placed towards the end of issues, in journals with content grouped by disease category (**Supplementary Table 5**).

Comparison of median Standardised Article Placement Indices (SAPIs)

Post hoc analyses of the differences in median SAPIs between genders, geographical regions, industry funding categories and disease categories are shown in **Supplementary Table 6 and Supplementary Figure 1**. Significant differences in article placement order were observed between disease categories, with all categories demonstrating greater median SAPIs (indicative of placement towards the back of journal issues) compared to rheumatoid arthritis (all $P < 0.001$).

The impact of article placement order on Altmetric scores and downloads

The impact of article placement order was evident in the meta-analysis results, which showed a higher Altmetric score (adjusted for journal) for articles published in the first three places of an issue compared with the last three, (mean difference in Altmetric score of 5.11, 95% CI 1.50, 8.71, $Z = 2.78$, $P = 0.005$) (**Figure 5**). The difference in Altmetric scores varied across

different disease categories (I^2 76%; $P < 0.001$), with the largest difference between positioning in the first three places and positioning in the last three places being observed for articles about rheumatoid arthritis and psoriatic arthritis.

Similarly, meta-analysis showed that articles published in the first three places of an issue had a higher download rate compared to articles in the last three places of an issue (pooled rate difference (95% CI) 442.1 (293.0, 591.2) downloads/article year, Z = 5.81, $P < 0.001$) (**Figure 5**). The difference in download rate between the first and last three articles was similar across different disease categories (I^2 24%; $P = 0.21$).

DISCUSSION

In this analysis of serial rheumatology journals, no relationship between article placement order and author gender or geographical region was observed. However, differences for funding source, research design, and disease category were apparent. There was more frequent positioning of industry-funded studies and randomised controlled trials towards the front of journal issues. Articles about rheumatoid arthritis were also more frequently positioned towards the front of journal issues, while articles about crystal arthritis, other connective tissue diseases, pediatric rheumatology, pain syndromes, systemic lupus erythematosus, systemic sclerosis and vasculitis towards the back of issues. Analyses of Altmetric scores and download rates suggested that article placement order influences research prominence, with earlier placed articles receiving more attention.

Medical journals are central to evidence-based practice and represent a key source of new knowledge for medical professionals.[22, 23] Unbiased publication practices are important in allowing a variety of perspectives and emphases to expand the scope of research and clinical practice. Although bias has been previously reported in academic journals based on

authorship ordering of genders,[9, 10] representation of geographical regions,[9, 11] and acceptance and time to publication based on industry sponsorship,[12] our analysis showed that of these factors only industry funding was associated with article placement order within serial rheumatology journals. This finding may reflect the placement of clinical trials towards the front of issues which likely made up the majority of industry-funded studies.

Articles about rheumatoid arthritis were preferentially placed towards the front of rheumatology journals, while other conditions, particularly pain syndromes, crystal arthritis, pediatric syndromes, and connective tissue diseases, were ordered towards the back. Rheumatoid arthritis was the disease category with the greatest number of articles, therefore giving it the greatest opportunity to be listed first, but our analyses accounted for the variation in article numbers between disease categories. Although rheumatoid arthritis is a very important rheumatic disease,[24] general rheumatology practice involves the diagnosis and treatment of a wide range of diseases.[25, 26] General rheumatology journals should ideally reflect that diversity of clinical practice. A similar distribution of articles on each disease category would therefore be expected if there was no bias for disease category.

The reason for the observed differences in article placement for disease category is unclear. Disease privileging in other fields of medical research has been reported, with some prevalent diseases with high global impact being under-funded and under-researched.[13-15] Crystal arthritis, osteoarthritis and pain syndromes are common; for example, prevalence estimates for US adults for gout are 3.9%,[27] for osteoarthritis are 13.4%,[28] and for low back pain are 26.4%.[29] However, these conditions may be viewed by rheumatologists and journal editors as less important or less severe.[30, 31] Our analysis of article placement order, which did not reflect prioritising of diseases based on epidemiology or severity, emphasises the disconnect between the prevalence of disease and health research. These perceptions of some rheumatic diseases have the potential to impact attitudes in clinical practice and contribute to

lower quality of care.[31, 32] Rheumatic diseases such as vasculitis, pediatric rheumatic disease, and scleroderma are less common, but can lead to major morbidity and reduced quality of life. Improving the impact and accessibility of research published on 'lower priority' or less common rheumatic diseases may have an important impact on clinicians' understanding about and attitudes towards these conditions in clinical practice.

Differences in article placement order for disease category was particularly evident in journals with disease-specific tables of contents sections within issues, rather than journals that did not group issue content by disease category. It has been suggested that grouping article content by disease category may improve the reader experience.[33] However, such decisions have the potential to further reduce readers' exposure to diseases that are already under-studied or less well understood. Editorial decisions to remove grouping by disease category, or to cycle the order of disease category groups for each issue may be a simple solution to overcome bias for disease category reflected in article placement order.

In our analysis, articles appearing in the first three places of an issue had higher Altmetric scores and download rates compared to articles appearing in the last three places of an issue. This finding may be attributed in part to the higher number of clinical trials published towards the front of issues, which generally have a greater impact [34], and is also consistent with prior studies which demonstrate the influence of the primacy effect on research prominence.[6-8] Collectively, these findings indicate that articles placed at the front of journal issues receive greater prominence. The prominence and impact of research published in journals has an important role in not only providing information to improve knowledge and treatment, but also in financing further research[35] and obtaining academic promotion.[36]

The current analysis has some limitations. Firstly, Altmetric and download data were not available from all journals included in the analysis, and it is unclear whether similar

differences are present across all journals. Secondly, citation rates were not evaluated because of the short time period between article publication and data extraction which would not have reflected true citation rates, which increase over time. Finally, this analysis did not explore other factors that may have contributed to article placement order such as quality, impact, or originality of the study, or the presence of prolific or "star" authors.[37] Further research may also focus on identifying factors influencing editorial decisions about the placement order of articles about different diseases. For example, we did observe that basic science articles were placed towards the back of an issue, suggesting that editors prioritise clinical research over laboratory-based research. A strength of this paper is the use of multiple methods of analysis to explore the relationship between disease category and article placement order, including an analysis of the distribution of article placement, an analysis of the difference in proportion of articles appearing in the first and last three places of an issue, and an analysis of the comparison of median article placement order between disease categories. Collectively, these results provide robust and detailed evidence that bias for industry funded studies, clinical trials and for certain disease categories is reflected in article placement order.

In conclusion, author gender and geographical region do not influence article placement order in serial rheumatology journals. However, bias for certain disease categories is reflected in article placement order. Article placement order may have an impact on research prominence, including Altmetric scores and download rate. Editorial choices about the serial position of articles within journals can influence prioritisation of certain diseases.

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Competing interests

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Author contributions

SS contributed towards acquisition, analysis and interpretation of the data. GG contributed towards design of the study and analysis and interpretation of the data. AG contributed towards design of the study and interpretation of the data. ND contributed towards design of the study, and acquisition and interpretation of the data. All authors were involved in drafting of the work or revising it critically for important intellectual content. All authors approved the final version to be published and agree to be accountable for all aspects of the work.

Data statement

All extracted data used in the analyses are available upon reasonable request from the corresponding author.

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Figure legends

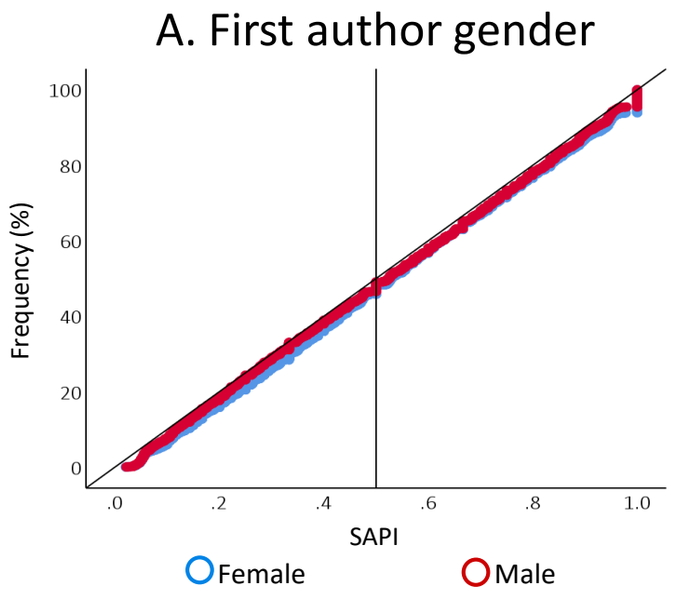
Figure 1. Cumulative distribution function plots of standardised article placement indices (SAPI) for first author gender (**A.**), senior author gender (**B.**), industry funding (**C.**), and first author's geographic region of affiliated institution (**D.**), and research design (**E.**). Left deviated distributions suggest prioritisation towards the front of journal issues.

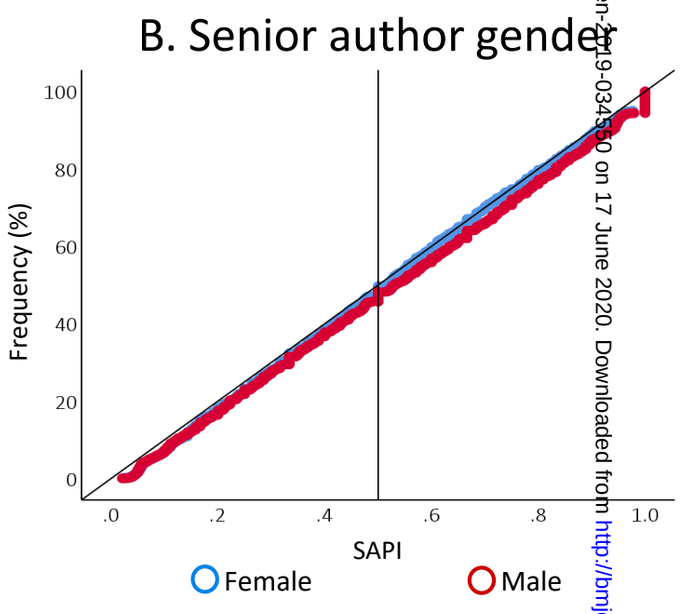
Figure 2. Cumulative distribution function plots of standardised article placement indices (SAPI) for each disease category. Left deviated distributions suggest prioritisation towards the front of journal issues.

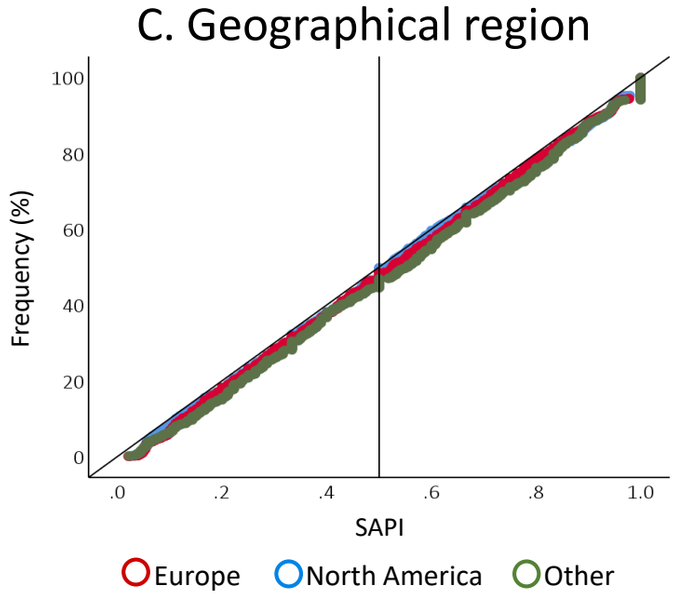
Figure 3. Percentage of articles (per disease category) published in first three and last three places of an issue (*P*-values indicate difference between proportions of articles in first and last three places of an issue).

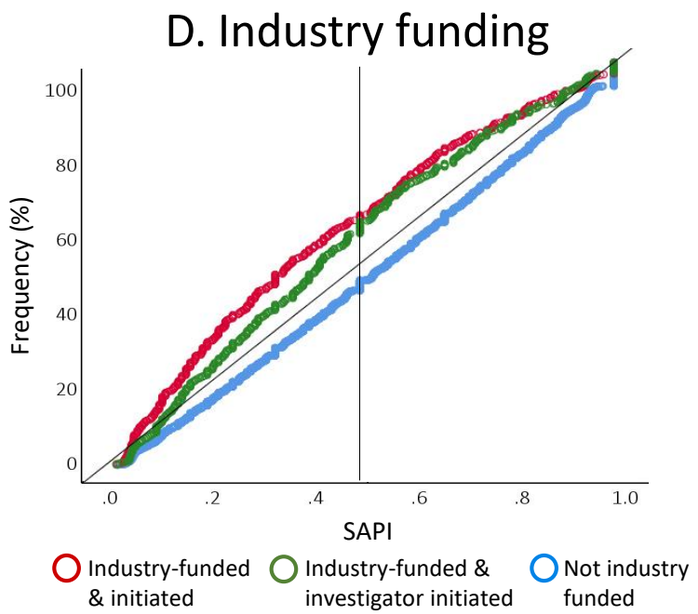
Figure 4. Cumulative distribution function plots of standardised article placement indices (SAPI) for each disease category for journals with (**A.**) and without (**B.**) contents grouped by disease. Left deviated distributions suggest prioritization towards the front of journal issues.

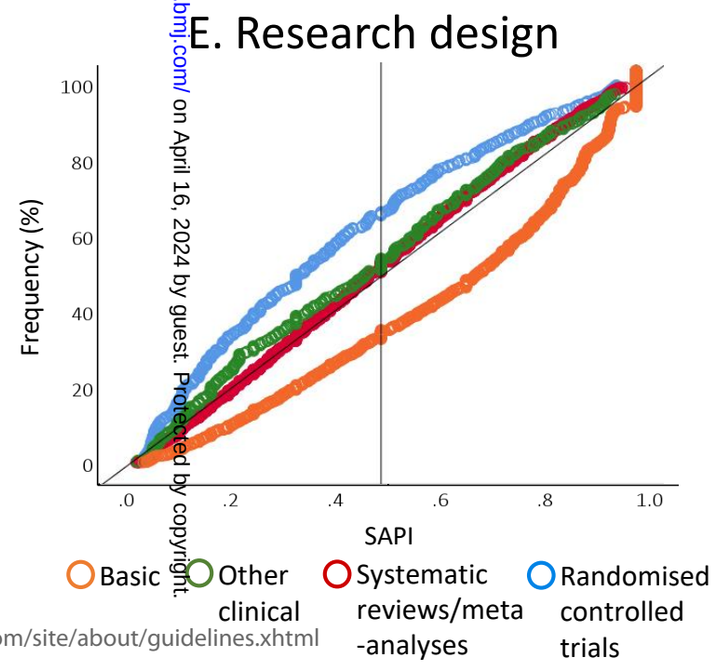
Figure 5. Forest plots showing the mean differences for each disease category for Altmetric scores (**A.**) and download rates (**B.**) between articles published in the first vs. last three places of an issue. Positive differences indicate a higher Altmetric score/download rate for articles published in one of the first three places of an issue. Differences in Altmetric scores are adjusted for journal. Download data was available from one journal. CTD: connective tissue disease.

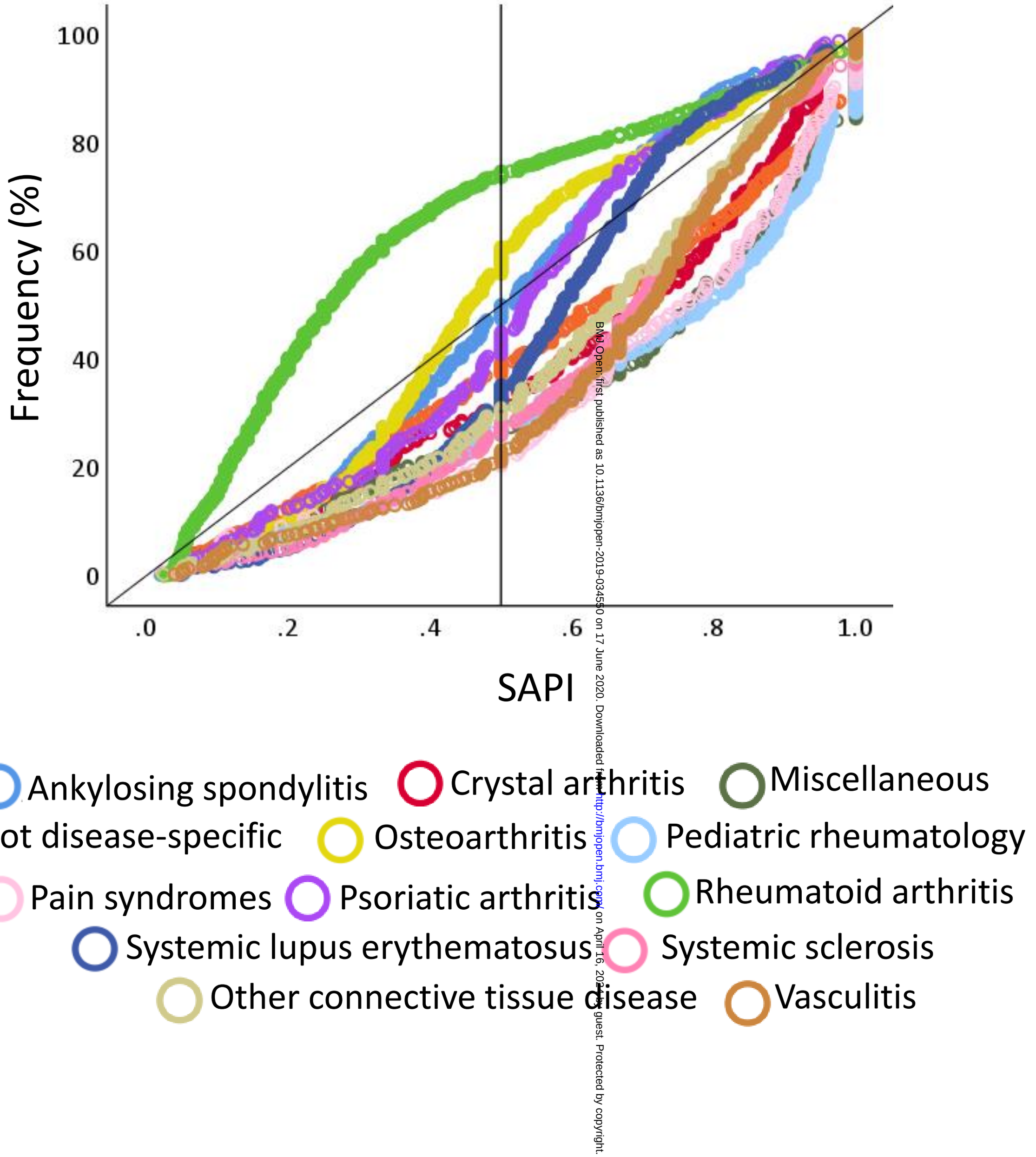


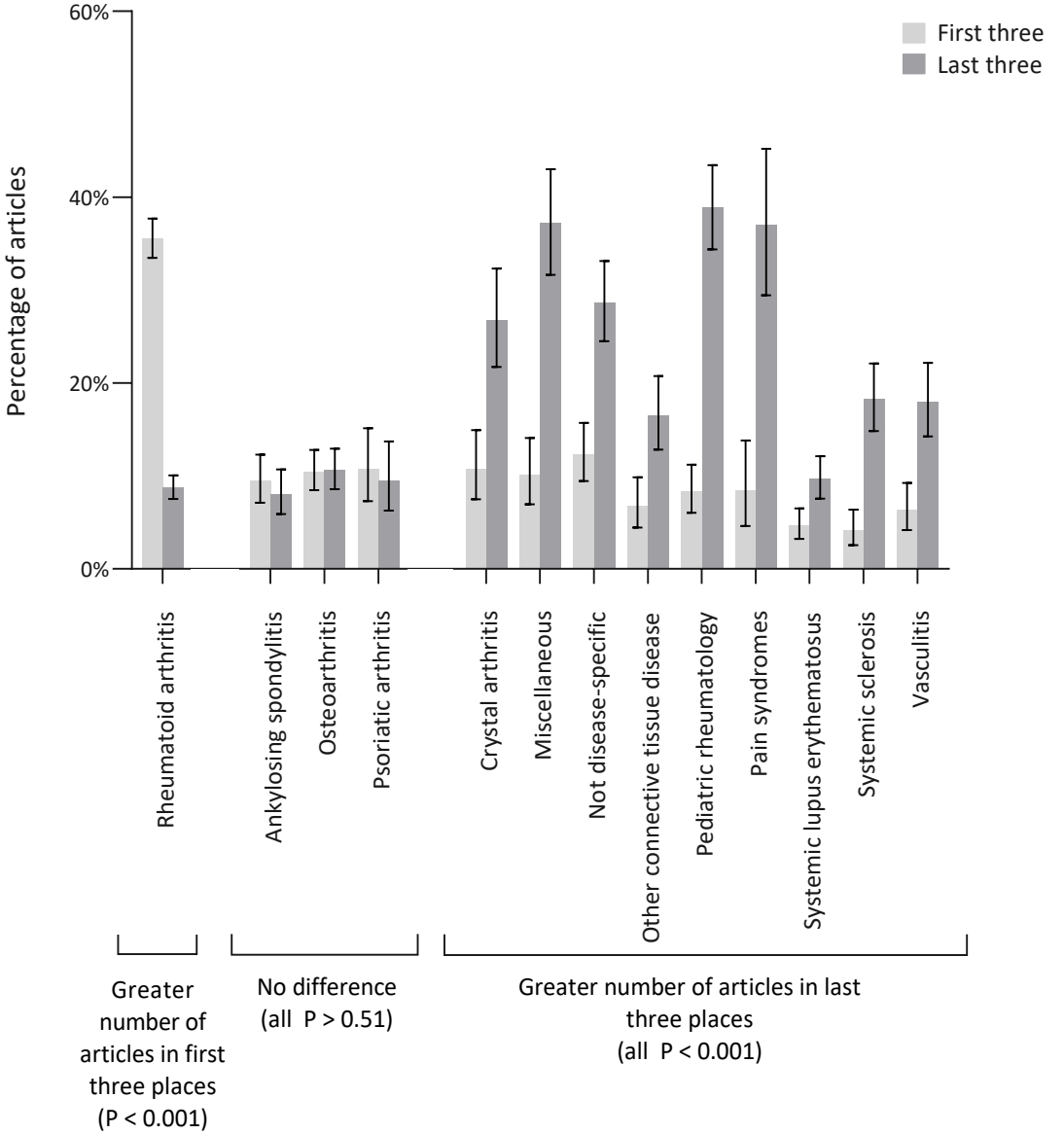




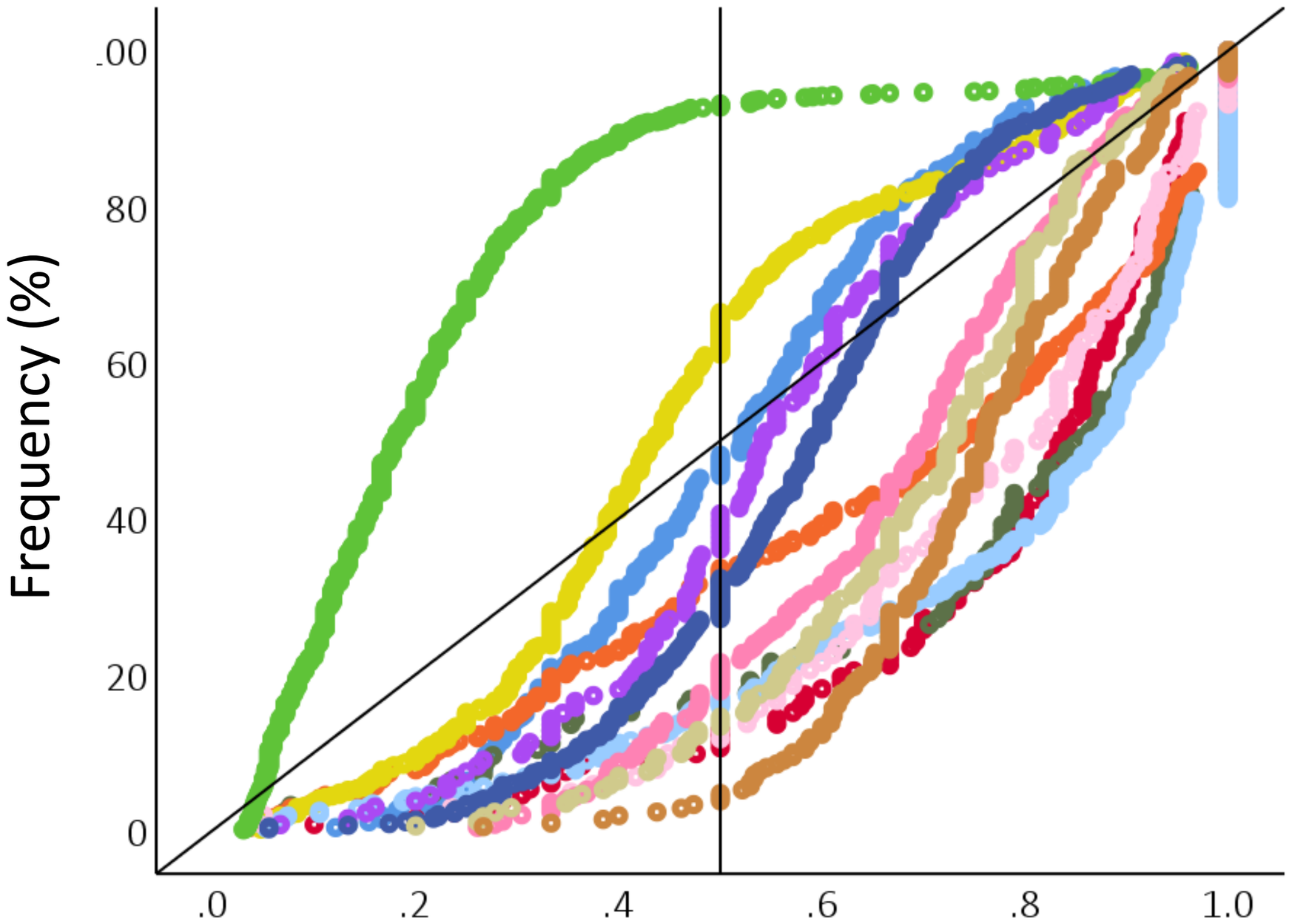




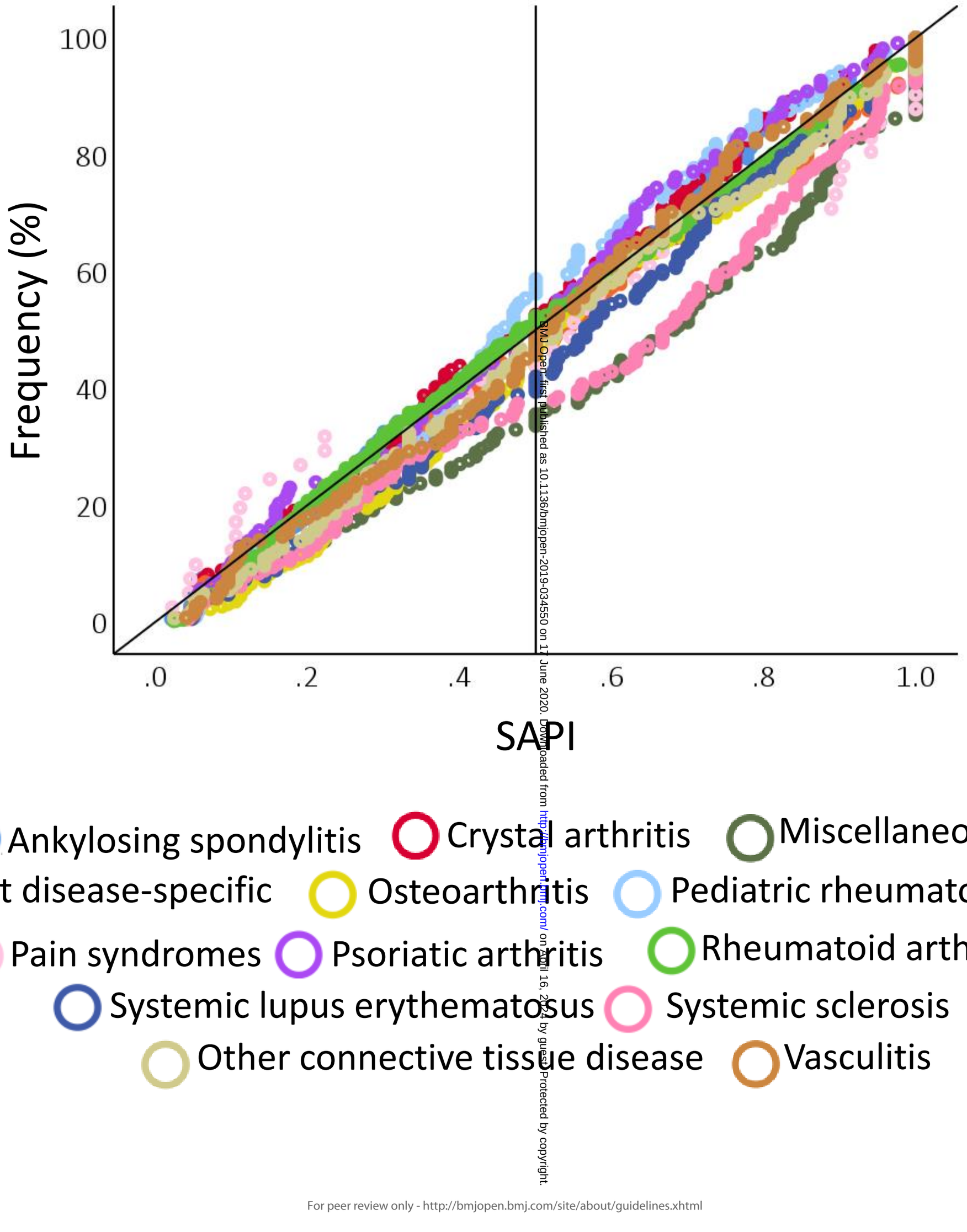




A. Journals with issue content grouped by disease



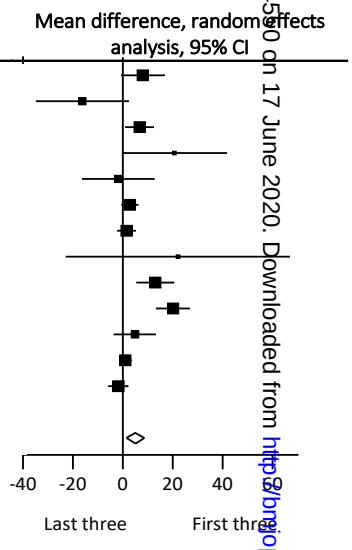
B. Journals without issue content grouped by disease



A. Differences in Altmetric scores between articles in first and last three places of an issue

	First three Mean score	N	Last three Mean score	N	Weight	Score difference	95% CI
Ankylosing spondylitis	14.19	32	6.10	31	7.44%	8.09	(-0.70, 16.88)
Crystal arthritis	9.10	21	25.23	39	2.90%	-16.14	(-34.85, 2.58)
Miscellaneous	10.95	20	4.18	50	9.93%	6.77	(0.99, 12.55)
Not disease-specific	28.47	36	7.73	66	2.40%	20.74	(-0.33, 41.82)
Osteoarthritis	18.47	47	20.26	47	4.20%	-1.79	(-16.35, 12.77)
Other CTDs	6.421	19	3.57	47	11.91%	2.85	(-0.58, 6.27)
Pediatric rheumatology	7.14	29	5.57	86	11.63%	1.57	(-2.21, 5.35)
Pain syndromes	48.36	11	26.10	29	0.61%	22.26	(-22.78, 67.30)
Psoriatic arthritis	13.00	17	3.00	17	8.38%	13.06	(5.46, 20.65)
Rheumatoid arthritis	24.16	434	4.03	156	9.01%	20.13	(13.29, 26.97)
Systemic lupus erythematosus	12.59	27	7.69	58	7.69%	4.90	(-3.55, 13.36)
Systemic sclerosis	3.88	17	2.81	69	12.50%	1.07	(-1.49, 3.63)
Vasculitis	2.68	22	4.41	37	11.42%	-1.72	(-5.77, 2.33)
Total		**732**		**732**	**100.0**	**5.11**	**(1.50, 8.71)**

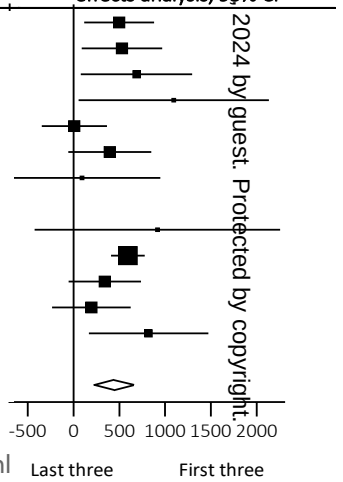
Heterogenity: $Tau^2 = 25.3$; $Chi^2 = 49.8$; $I^2 = 75.9\%$ ($P < 0.001$)
Test for overall effect: Z = 2.78; P = 0.005



B. Differences in download rates between articles in first and last three places of an issue

	First three Mean score	N	Last three Mean score	N	Weight	Rate difference	95% CI
Ankylosing spondylitis	842.8	17	344.9	10	10.9%	497.9	(115.6, 880.3)
Crystal arthritis	726.3	9	198.1	5	8.88%	528.3	(89.2, 967.3)
Miscellaneous	1073.5	7	385.3	12	5.18%	688.1	(78.7, 1297.6)
Not disease-specific	1430.0	15	336.0	15	1.95%	1093.9	(54.7, 2133.1)
Osteoarthritis	465.5	13	457.2	22	12.04%	8.2	(-347.9, 364.4)
Other CTDs	785.3	5	389.1	14	8.40%	396.2	(-58.7, 851.1)
Pediatric rheumatology	758.2	6	626.0	4	3.07%	132.2	(-683.7, 948.1)
Pain syndromes	1110.5	3	346.4	1	0.00%	Excluded	
Psoriatic arthritis	1408.0	14	491.8	3	1.20%	916.2	(-426.3, 2258.7)
Rheumatoid arthritis	952.2	76	358.8	54	24.23%	593.4	(409.2, 777.6)
Systemic lupus erythematosus	880.0	11	538.7	12	10.36%	341.3	(-54.6, 737.2)
Systemic sclerosis	480.6	5	286.8	25	9.19%	193.9	(-235.4, 623.1)
Vasculitis	961.3	3	142.0	6	4.59%	819.3	(165.95, 1472.7)
Total		**183**		**184**	**100.0**	**442.1**	**(293.0, 591.2)**

Heterogeneity: $Tau^2 = 15400$; $Chi^2 = 14.4$; $I^2 = 23.7\%$ ($P = 0.211$)
Test for overall effect: Z = 5.81; P < 0.001



SUPPLEMENTARY MATERIAL

Supplementary Table 1. Journal characteristics

	Publisher	Country of publication	2016 Impact Factor	Relevant affiliated society	Issues per year	Contents grouped by disease	Total number of articles included, n	Number of included articles per issue, mean (SD)
Annals of the Rheumatic Diseases	BMJ Publishing Group Ltd	United Kingdom	12.811	European League Against Rheumatism	12	No	1374	13.2 (9.4)
Arthritis & Rheumatology	John Wiley & Sons	United States	6.918	American College of Rheumatology	12	Yes	1367	12.5 (7.6)
Rheumatology	Oxford University Press	United Kingdom	4.818	British Society for Rheumatology	12	No	1158	10.2 (5.7)
Seminars in Arthritis and Rheumatism	Elsevier	United States	4.498	None	6	Yes	403	7.3 (4.1)
Joint Bone Spine	Elsevier	United States	3.329	French Society of Rheumatology	6	No	239	4.6 (2.6)
Arthritis Care & Research	John Wiley & Sons	United States	3.319	American College of Rheumatology, Association of Rheumatology Health Professionals	12	Yes	1098	9.6 (5.4)
The Journal of Rheumatology	Journal of Rheumatology Publishing Company Limited	Canada	3.150	Canadian Rheumatology Association	12	Yes	1148	10.3 (6.1)

Supplementary Table 2. Number of articles within each disease category for crystal arthritis, miscellaneous and other connective tissue diseases

	Frequency	Percent
Crystal arthritis **(n = 269)**		
Gout	260	96.7
Calcium crystal diseases	9	3.3
Miscellaneous Disease **(n = 277 articles)**		
Regional musculoskeletal syndromes	48	17.3
Osteoporosis	22	7.9
IgG4-related disease	20	7.2
FMF	20	7.2
Polymyalgia rheumatica	19	6.9
CAPS	16	5.8
Still's disease	10	3.6
Septic arthritis	8	2.9
Fibrosis	8	2.9
Sarcoidosis	7	2.5
Chikungunya Virus	7	2.5
SAPHO syndrome	6	2.2
TRAPS	5	1.8
Polychondritis	5	1.8
Ehlers-Danlos Syndrome	4	1.4
Lyme disease	4	1.4
Alkaptonuria	4	1.4
Hemophagocytic syndromes	3	1.1
Vertebral fractures	2	0.7
Uveitis	2	0.7
Undifferentiated arthritis	2	0.7
Tuberculosis	2	0.7
Periodic fever syndrome	2	0.7
Löfgren syndrome	2	0.7
Erdheim-Chester disease	2	0.7
Dupuytren's disease	2	0.7
ACPA-negative undifferentiated arthritis	1	0.4
Yellow fever	1	0.4
Whipple disease	1	0.4
Vertebral endplate lesions	1	0.4
Tumoral calcinosis	1	0.4
Tenosynovial giant cell tumor	1	0.4
Systemic autoinflammatory disease (SAID)	1	0.4
Schnitzler's syndrome	1	0.4
Ribbing disease	1	0.4
Receptor-associated periodic syndrome	1	0.4
Pyogenic sterile arthritis pyoderma gangrenosum and acne (PAPA) syndrome	1	0.4
Pyogenic arthritis	1	0.4
Primary angiitis of the CNS	1	0.4
Preeclampsia	1	0.4
Pigmented villonodular synovitis	1	0.4
Periodic fever, aphthous stomatitis, pharyngitis, and cervical adenitis (PFAPA) syndrome	1	0.4

Paraneoplastic rheumatic syndrome	1	0.4
Palindromic rheumatism	1	0.4
Paget's disease	1	0.4
Osteonecrosis	1	0.4
Osteomyelitis	1	0.4
NOD2-associated autoinflammatory diseases	1	0.4
Muckle-wells syndrome	1	0.4
Mikulicz's disease	1	0.4
Mevalonate kinase deficiency	1	0.4
Medial meniscal tears	1	0.4
Macrophage activation syndrome	1	0.4
Leri's pleonosteosis	1	0.4
Kikuchi-Fujimoto disease	1	0.4
Joint hypermobility syndrome	1	0.4
Immune reconstitution inflammatory syndrome	1	0.4
Hereditary recurrent fever syndromes	1	0.4
Hereditary haemochromatosis	1	0.4
Haploinsufficiency of A20	1	0.4
Glomerulonephritis	1	0.4
Gaucher disease	1	0.4
Femoral fractures	1	0.4
Fabry disease	1	0.4
Ebola virus	1	0.4
Discitis	1	0.4
Chronic graft-versus-host disease	1	0.4
Blau syndrome	1	0.4
Biphosphate trochanteric fracture	1	0.4
Amyloidosis	1	0.4
Aicardi-Goutières syndrome	1	0.4
Other connective tissue disease **(n = 339 articles)**		
Sjogren's syndrome	174	51.3
Inflammatory myositis	115	33.9
Antiphospholipid syndrome	41	12.1
Mixed connective tissue disease	7	2.1
CTD-associated interstitial lung disease	1	0.3
Undifferentiated connective tissue disease	1	0.3

Supplementary Table 3. Difference in distribution of standard article placement indices (SAPI) for each author gender, geographical region, industry finding category and research design

	N (%)	SAPI, mean (SD)	Two-sample Kolmogorov-Smirnov Z test Effect size (KS D)	FDR-adjusted P
First author gender				
Female	3517 (52.0%)	0.53 (0.29)	0.03	0.19
Male	3250 (48.0%)	0.52 (0.29)		
Last author gender				
Female	2359 (34.8%)	0.52 (0.28)	0.04	0.017
Male	4412 (65.2%)	0.53 (0.29)		
Geographical region				
Europe	3486 (51.4%)	0.53 (0.29)	(reference)	-
North America	2177 (32.1%)	0.52 (0.29)	0.02	0.57
Other	1124 (16.6%)	0.52 (0.29)	0.03	0.93
Industry funding				
Industry funded and initiated	640 (9.4%)	0.42 (0.28)	0.19	<0.001
Industry funded and investigator initiated	596 (8.8%)	0.45 (0.29)	0.17	<0.001
Not industry funded	5551 (82.0%)	0.55 (0.29)	(reference)	-
Research design				
Basic science	1395 (20.6%)	0.64 (0.28)	(reference)	-
Other clinical research	4466 (65.8%)	0.51 (0.28)	0.22	<0.001
Randomised controlled trials	488 (7.2%)	0.41 (0.29)	0.34	<0.001
Systematic literature reviews/meta-analyses	438 (6.4%)	0.49 (0.29)	0.24	<0.001

SAPI = standard articles placement index. Lower SAPI scores equate to articles ordered at the front of issues, while higher SAPI scores equate to articles ordered at the end of issues.

Supplementary Table 4. Number of articles appearing in at least one article in first and last three articles of an issue for author gender, geographical region of affiliated institution, industry funding category, and disease category

	Total articles	First three N	% of total	Last three N	% of total	Odds ratio (OR)[a]	95% CI for OR	*P*[b]
First author gender								
Female	3517	537	15.3%	586	16.7%	0.90	0.79, 1.02	0.17
Male	3250	557	17.1%	509	15.7%	1.11	0.98, 1.27	0.17
Last author gender								
Female	2359	393	16.7%	355	15.0%	1.13	0.97, 1.32	0.17
Male	4412	705	16.0%	737	16.7%	0.95	0.85, 1.01	0.37
Geographical region								
Europe	3486	573	16.4%	556	16.0%	1.04	0.91, 1.18	0.68
North America	2177	362	16.6%	352	16.2%	1.03	0.88, 1.21	0.68
Other	1124	163	14.5%	190	16.9%	0.83	0.66, 1.05	0.35
Industry funding								
Industry-funded and initiated	640	104	16.3%	109	17.0%	0.95	0.70, 1.27	0.71
Industry-funded and investigator-initiated	596	87	14.6%	111	18.6%	0.75	0.55, 1.01	0.09
Not industry-funded	5551	907	16.3%	878	15.8%	1.04	0.94, 1.15	0.09
Research type								
Basic science	1395	106	7.6%	366	26.2%	0.23	0.18, 0.29	<0.001
Other clinical research	4466	757	17.0%	606	13.6%	1.30	1.16, 1.46	<0.001
Randomised controlled trials	488	129	26.4%	53	10.9%	2.95	2.08, 4.18	<0.001
Systematic literature reviews / meta-analyses	438	106	24.2%	73	16.7%	1.60	1.14, 2.23	0.003
Disease category								
Ankylosing spondylitis	496	47	9.5%	40	8.1%	1.19	0.77, 1.86	0.51
Crystal arthritis[c]	269	29	10.8%	72	26.8%	0.33	0.21, 0.53	<0.001
Miscellaneous	277	28	10.1%	103	37.2%	0.19	0.12, 0.30	<0.001
Not disease-specific	422	52	12.3%	121	28.7%	0.35	0.24, 0.50	<0.001
Osteoarthritis	773	81	10.5%	82	10.6%	0.99	0.71, 1.37	0.934
Other connective tissue diseases	339	23	6.8%	56	16.5%	0.37	0.22, 0.61	<0.001
Pediatric rheumatology	443	37	8.4%	172	38.8%	0.14	0.10, 0.21	<0.001
Pain syndromes	143	12	8.4%	53	37.1%	0.16	0.08, 0.31	<0.001
Psoriatic arthritis[c]	242	26	10.7%	23	9.5%	1.15	0.63, 2.07	0.71
Rheumatoid arthritis	1946	692	35.6%	170	8.7%	5.77	4.80, 6.92	<0.001
Systemic lupus erythematosus	642	30	4.7%	62	9.7%	0.46	0.29, 0.72	0.001
Systemic sclerosis	433	18	4.4%	79	18.2%	0.19	0.11, 0.33	<0.001
Vasculitis	362	23	6.4%	65	18.0%	0.31	0.19, 0.51	<0.001

[a]The odds of being in at least one article in the first three places of an issue; [b]FDR-adjusted Mid-P exact P-value; [c]One article in each of 'Crystal arthritis' and 'Psoriatic arthritis' came from issues which included 5 articles and were therefore counted in both the 'first' and 'last' three categories.

Supplementary Table 5. Difference in cumulative density function distribution of standard article placement indices (SAPI) between journals with and without contents grouped by disease for articles with related editorials and for each disease category

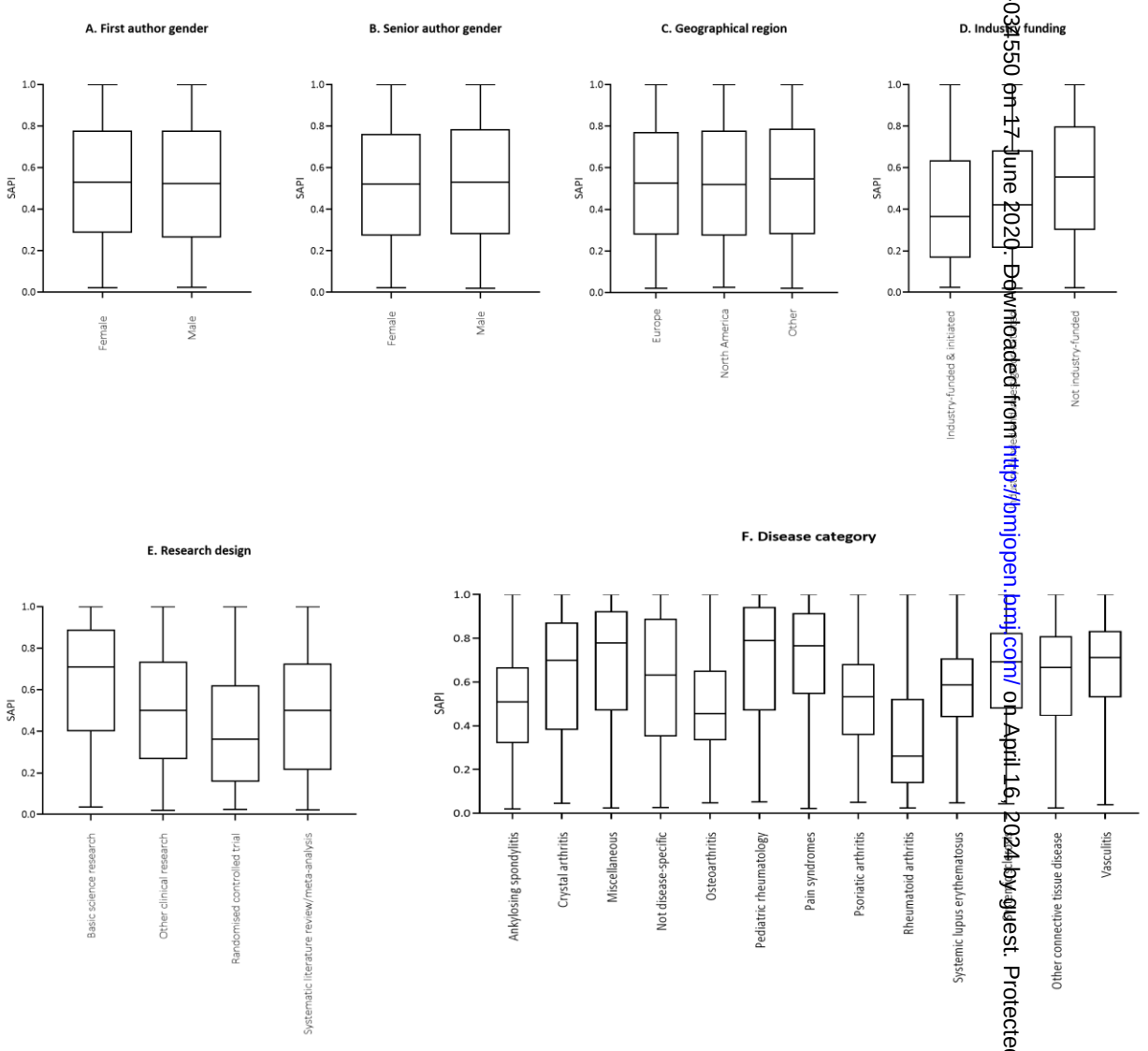
	Journals with contents not grouped by disease			Journals with contents grouped by disease			Two-sample Kolmogorov-Smirnov Z test[b]	
	N (%)	SAPI[a]		N (%)	SAPI[a]		Effect size (KS D)	FDR-adjusted P
		Mean	SD		Mean	SD		
Ankylosing spondylitis	228 (8.2%)	0.49	0.28	268 (6.7%)	0.52	0.19	0.20	<0.001
Crystal arthritis	137 (4.9%)	0.49	0.28	132 (3.3%)	0.78	0.20	0.50	<0.001
Miscellaneous	152 (5.5%)	0.62	0.30	125 (3.1%)	0.76	0.26	0.29	<0.001
Not disease-specific	178 (6.4%)	0.53	0.30	244 (6.1%)	0.66	0.29	0.22	<0.001
Osteoarthritis	231 (8.3%)	0.55	0.27	542 (13.5%)	0.47	0.22	0.20	<0.001
Other connective tissue diseases	167 (6.0%)	0.49	0.29	172 (4.3%)	0.70	0.17	0.36	<0.001
Pediatric rheumatology	121 (4.4%)	0.48	0.26	322 (8.0%)	0.77	0.25	0.50	<0.001
Pain syndromes	41 (1.5%)	0.54	0.35	102 (2.5%)	0.75	0.21	0.36	0.001
Psoriatic arthritis	109 (3.9%)	0.48	0.27	133 (3.3%)	0.56	0.20	0.22	0.005
Rheumatoid arthritis	881 (31.8%)	0.51	0.29	1065 (26.5%)	0.23	0.20	0.49	<0.001
Systemic lupus erythematosus	193 (7.0%)	0.56	0.28	449 (11.2%)	0.58	0.17	0.19	<0.001
Systemic sclerosis	182 (6.6%)	0.60	0.30	251 (6.3%)	0.68	0.18	0.26	<0.001
Vasculitis	151 (5.4%)	0.51	0.28	211 (5.3%)	0.75	0.14	0.50	<0.001

[a]Lower SAPI scores equate to articles ordered at the front of issues, while higher SAPI scores equate to articles ordered at the end of issues. [b]Test of difference in distribution of SAPI between journals with and without contents grouped by disease sections.

Supplementary Table 6. Comparison of median standardised article placement index (SAPI) between genders of first and last authors, geographical regions, industry funding categories and disease categories.

	N of articles	SAPI[a]		Difference in median SAPI	
		Median (IQR)	Min-max	Effect size (Cohen's d)	FDR-adjusted P- value
First author gender					
Female	3517	0.53 (0.49)	0.02-1.00	0.04	0.11
Male	3250	0.52 (0.51)	0.02-1.00		
Last author gender					
Female	2359	0.52 (0.49)	0.02-1.00	0.05	0.07
Male	4412	0.23 (0.51)	0.02-1.00		
Geographical region					
Europe	3486	0.53 (0.50)	0.02-1.00		
North America	2177	0.51 (0.51)	0.02-1.00	0.02	0.26
Other	1124	0.56 (0.51)	0.02-1.00		
Industry funding					
Industry funded and initiated	640	0.36 (0.47)	0.02-1.00		
Industry funded and investigator initiated	596	0.42 (0.47)	0.02-1.00	0.30	<0.001
Not industry funded	5551	0.56 (0.49)	0.02-1.00		
Research type					
Basic science	1395	0.71 (0.28)	0.03-1.00		
Other clinical research	4466	0.50 (0.47)	0.02-1.00	0.19	<0.001
Randomised controlled trials	488	0.36 (0.46)	0.02-1.00		
Systematic literature reviews/meta-analyses	438	0.50 (0.51)	0.02-1.00		
Disease category					
Ankylosing spondylitis	496	0.50 (0.35)	0.02-1.00	0.53	<0.001
Crystal arthritis	269	0.70 (0.50)	0.05-1.00	0.59	<0.001
Miscellaneous	277	0.78 (0.45)	0.02-1.00	0.68	<0.001
Not disease-specific	422	0.63 (0.54)	0.03-1.00	0.64	<0.001
Osteoarthritis	773	0.45 (0.32)	0.05-1.00	0.58	<0.001
Other connective tissue diseases	339	0.67 (0.37)	0.02-1.00	0.66	<0.001
Pediatric rheumatology	443	0.79 (0.47)	0.05-1.00	0.86	<0.001
Pain syndromes	143	0.75 (0.37)	0.02-1.00	0.51	<0.001
Psoriatic arthritis	242	0.53 (0.33)	0.05-1.00	0.43	<0.001
Rheumatoid arthritis	1946	0.26 (0.39)	0.02-1.00	(reference category)	-
Systemic lupus erythematosus	642	0.58 (0.27)	0.05-1.00	0.78	<0.001
Systemic sclerosis	433	0.69 (0.35)	0.04-1.00	0.79	<0.001
Vasculitis	362	0.71 (0.30)	0.04-1.00	0.74	<0.001

[a]*Lower SAPI scores equate to articles ordered at the front of issues, while higher SAPI scores equate to articles ordered at the end of issues.*



Supplementary Figure 1. Box plots showing differences in standardised article placement indices (SAPI) for first author gender (**A.**), senior author gender (**B.**), industry funding (**C.**), first author's geographic region of affiliated institution (**D.**), research design (**E.**) and disease category (**F.**)