Altmetrics can capture research evidence: an analysis across types of studies in COVID-19 literature

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Abstract

COVID-19 has greatly impacted science. It has become a global research front that constitutes a unique phenomenon of interest for the scientometric community. Accordingly, there has been a proliferation of descriptive studies on COVID-19 papers using altmetrics. Social media metrics serve to elucidate how research is shared and discussed, and one of the key points is to determine which factors are well-conditioned altmetric values. The main objective of this study is to analyze whether the altmetric mentions of COVID-19 medical studies are associated with the type of study and its level of evidence. Data were collected from the *PubMed* and *Altmetric.com* databases. A total of 16,672 study types (e.g., case reports, clinical trials, or meta-analyses) that were published in the year 2021 and that had at least one altmetric mention were retrieved. The altmetric indicators considered were *altmetric attention score* (AAS), news mentions, *Twitter* mentions, and *Mendeley* readers. Once the dataset of COVID-19 had been created, the first step was to carry out a descriptive study. Then, a normality hypothesis was evaluated by means of the Kolmogorov–Smirnov test, and since this was significant in all cases, the overall comparison of groups was performed using the nonparametric Kruskal–Wallis test. When this test rejected the null hypothesis, pairwise comparisons were performed with the Mann–Whitney *U* test, and the intensity of the possible association was measured using Cramer's *V* coefficient. The results suggest that the data do not fit a normal distribution. The Mann–Whitney *U* test revealed coincidences in five groups of study types: The altmetric indicator with most coincidences was news mentions, and the study types with the most coincidences were the systematic reviews together with the meta-analyses, which coincided with four altmetric indicators. Likewise, between the study types and the altmetric indicators, a weak but significant association was observed through the chi-square and Cramer's *V*. It can thus be concluded that the positive association between altmetrics and study types in medicine could reflect the level of the "pyramid" of scientific evidence.

Keywords

COVID-19; Altmetrics; Social media metrics; *Twitter*; News; *Mendeley*; Citations; Bibliometrics; Study type; *PubMed*; *Altmetric.com*.

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1. Introduction

COVID-19 has affected society worldwide as an unprecedented challenge (**Chriscaden**, 2020). The fact that this exceptional situation has greatly impacted science is attested to by an exponential explosion of scientific literature (**Torres-Salinas**, 2020; **Torres-Salinas** *et al.*, 2020). Along with the increase in publications, there were international calls for cooperation and openness of research to find a solution. This meant a unique opportunity for an open science revolution, which eventually faded away (**Brainard**, 2021). In addition, given the global impact of the pandemic and its effects on multiple aspects of society, COVID-19 attracted the attention of researchers in areas beyond medicine from the very beginning (**Aristovnik** *et al.*, 2020). Thus, COVID-19 has become a consolidated global research front, of great interest to the scientometric community, among others.

Bibliometric properties of this explosion of publications have been studied in detail, and particularities have been highlighted; **Zhang** *et al.* (2020) studied the early global response of researchers in comparison with other outbreaks; **Nane** *et al.* (2022) developed predictive models of expected publications to show the exceptional growth patterns of the scientific literature on COVID-19; **Pinho-Gomes** *et al.* (2020) analyzed the gender gap in the early literature and found that only a third of the authors were women; **Zhang** *et al.* (2021) detected certain changes in research interests after the pandemic peak, while others resume previous research lines. Furthermore, the impact of these new publications on bibliometric indicators has been studied (**Fassin**, 2021). There has also been a proliferation of descriptive studies examining new sources and datasets related to COVID-19. For instance, **Colavizza** *et al.* (2021) explored and detailed the content of new bibliographic data sources, whereas **Kousha** and **Thelwall** (2020) compared the coverage of the scholarly databases on COVID-19 publications, pointing to *Dimensions* as the most comprehensive.

Furthermore, different proposals have been developed to understand how these new publications are shared and discussed in different social media through "altmetrics" (**Priem**, 2014). These social media metrics have proven useful for understanding aspects of science communication beyond traditional channels (**Arroyo-Machado** *et al.*, 2021). Regarding COVID-19-related research, **Kousha** and **Thelwall** (2020) studied the altmetric impact of COVID-19 publications on different social media platforms and found that early altmetric mentions such as tweets reflect a positive relationship with later citations. *Twitter*, in particular, is one of the main social media studied; it has been the object of numerous studies exploring diverse communities of users and interactions produced around anti-vaccine movements and disinformation (**Hayawi** *et al.*, 2022; **Marcec**; **Likic**, 2022; **Van-Schalkwyk** *et al.*, 2020). Despite the risks on *Twitter*, **Haunschild** and **Bornmann** (2021) saw its potential as an early warning system for identifying potentially problematic information. Beyond *Twitter*, there are also other suggestions. **Fraumann** and **Colavizza** (2022) reviewed and identified the important role that both news and blogs have played in science communication during the pandemic. In addition, **Colavizza** (2020) observed efforts by the *Wikipedia* community to incorporate the main research findings by referencing relevant publications.

The exceptionality of this situation resulting from the pandemic has thus been demonstrated, showing remarkable differences compared with other related phenomena, or already known patterns. There are differences between the various types of medical research outputs and the impact or attention they receive; one example is the role played by preprints (**Majumder**; **Mandl**, 2020; **Van-Schalkwyk**; **Dudek**, 2022). From the beginning of the pandemic, despite the fact that it marked a period in which studies focused so much on a single topic, there was considerable concern that the content and quality of this research might not meet public health needs (**Odone** *et al.*, 2020). This concern eventually became a reality; it was found that the quality and evidence of the study types of many papers was below the usual standards (**Jung** *et al.*, 2021). Therefore, the COVID-19 publications could provide an opportunity to study whether the characteristics, especially the type of medical research study, are related to the attention they receive in the main social media. In other words, the metric differences that may exist between, for example, a "case report" or a "clinical trial" could be studied.

This is possible because the field of Health Sciences has a classification of typologies, in which differences in scientific evidence and clinical value can be found (**Röhrig** *et al.*, 2009). Databases such as *Embase* or *Medline* classify their articles according to study type. It have been demonstrated that the study type is associated with the citation rates (**Okike** *et* *al.*, 2011; **Patsopoulos** *et al.*, 2005). For example, this phenomenon occurs with systematic reviews that received double the number of citations compared with nonsystematic reviews (**Bhandari** *et al.*, 2004; **Montori** *et al.*, 2003). Regarding altmetrics, a similar relationship has also been found between mentions and document type, as is the case with editorial materials, which have received a high level of attention on social media despite rarely being cited (**Haustein**; **Costas**; **Larivière**, 2015). But there is no literature that explores the impact that the research study type and evidence level may have on altmetric mentions. Our main objective is to analyze whether the altmetric attention received by COVID-19 medical studies is associated with the research study type and evidence level. To achieve this main objective, the following specific objectives were set:

1. Calculate the most relevant altmetrics for the papers published on COVID-19, considering the type of study as the main variable
2. Determine through different statistical tests if there are significant differences in the values observed in each type of study
3. Perform a ranking of the different types of studies considering their altmetrics and compare them with the traditional evidence pyramids

This paper is an considerable expansion of a preliminary study presented at the *STI 2022* (**Valderrama**; **Torres-Salinas**, 2022).

2. Methodology

We collected data from two sources: *PubMed* and *Altmetric.com*. Data were retrieved on November 21, 2022. Firstly, *PubMed* was used to retrieve the bibliographic records of the COVID-19 scholarly outputs published in the year 2021. Specifically, the search was carried out through *PubMed Clinical Queries*, using the following query:

> (COVID-19[MeSH Terms] OR SARS-CoV-2[MeSH Terms] OR coronavirus [MeSH Terms]) AND ("2021/01/01"[Date - Publication]: "2021/12/31"[Date - Publication])

This search resulted in a total of 93,024 publications that were classified according to the study types that were assigned directly by the publishers or the Index Section of the National Library of Medicine (NLM). For our aims, the following study types were considered: (1) case reports, (2) clinical trials, (3) consensus development conferences and guidelines, (4) reviews (all those that were systematic review were omitted), (5) systematic reviews, (6) meta-analyses, and (7) observational studies. This reduced the total number of publications to 20,668. The distribution of publications by study type was unequal, with the majority being reviews (9,873), followed in smaller numbers by case reports (4,254) and observational studies (3,117). After this came systematic reviews (2,101), meta-analyses (1,358), and clinical trials (1,325), and in last place consensus development conferences and guidelines (143).

Mentions were retrieved using *Altmetric.com* using the digital object identifier (DOI). *Altmetric.com* had indexed 16,672 from *PubMed* that had at least one mention. Regarding the selection of social media metrics, it is necessary to point out a common problem in such studies –the unequal number of metrics counted by source (**Zahedi** *et al*., 2014). First, we removed some sources according to the following criteria: (a) platforms with an irrelevant number of mentions (e.g., *YouTube* or *Stack Overflow*, (b) platforms with a strong geographical component (e.g., *Weibo* and *Reddit*), and (c) platforms that no longer exist or do not work (e.g., *LinkedIn*, *Google+*, *Sina Weibo*, and *Pinterest*). Second, to ensure statical validity, a threshold of 30% of publications with at least one mention was established. Finally, the metrics selected were: news mentions, *Twitter* mentions, and *Mendeley* readers. Likewise, *Dimensions* citations were considered so that a comparison with traditional bibliometric indicators could be undertaken.

Descriptive statistics were used to study the distribution and establish significant differences in altmetric mentions by type of study. First, we applied the Kruskal–Wallis test to contrast the hypothesis of equality of the medians between the variables to identify potential differences in performance (**Samuels** *et al*., 2011). Second, pairwise comparisons were carried out using the Mann–Whitney *U* test to check whether there were significant differences between two variables; for this purpose, the test calculated the *U* value. Finally, we used a test of independence based on the chi-square statistic on the contingency table of joint frequencies generated by the Mann–Whitney test, such that, when $p < 0.05$, we could conclude that there was a similarity between two variables, and therefore a similar level of evidence.

3. Results

3.1. Descriptive analysis

The cumulative sums of values by metric and study type are shown in Figure 1, where it can be clearly seen that reviews had the highest values for all metrics except for news mentions. This can be explained by the fact that it was the most abundant study type, representing 49% of the publications with altmetrics that were studied. After the reviews, clinical trials stood out in terms of altmetric attention score (AAS) and *Twitter* mentions. In the rest of the study types, the altmetrics showed a similar dynamic.

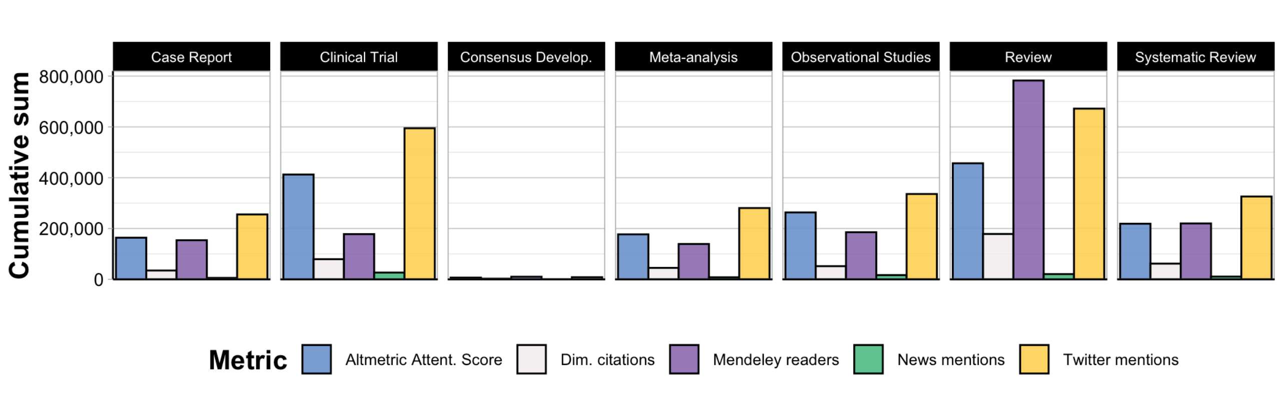

Figure 1. Cumulative sums of values by metric and study type of COVID-19 publications

Table 1. Descriptive statistics of COVID-19 publications and their metrics by study type

General metrics			Median values (interquartile range)				
Study type according *PubMed* database	Number of publications	Publications with mentions	*Altmetric attention score*	News mentions	*Twitter* mentions	*Mendeley* readers	*Dimensions* citations
1. Case report	4,254	2,984	4 (1-14)	0 (0-1)	3 (1-16)	37 (22-59)	5 (1-12)
2. Clinical trial	1,325	1,169	12 (4-82)	0 (0-3)	10 (3-61)	87 (51-152)	13 (5-39)
3. Meta-analysis	1,358	1,196	10 (3-37)	0 (0-1)	10 (4-35)	75 (43-137)	17 (8-38)
4. Observational studies	3,117	2,460	7 (2-24)	0 (0-1)	6 (2-24)	55 (32-90)	9 (3-19)
5. Consensus development	143	117	14 (4-49)	0 (0-2)	15 (2-50)	63 (35-113)	9 (3-22)
6. Systematic review	2,101	1,885	9 (3-33)	0 (0-1)	10 (4-33)	79 (46-136.75)	15 (6-34)
7. Review	9,873	8,177	7 (2-19)	0 (0-1)	5 (2-20)	59 (34-104)	9 (3-21)
All	20,668	16,672	7 (2-22)	0 (0-1)	6 (2-24)	57 (33-101)	9 (3-22)

In general, clinical trials and consensus development conferences and guidelines were the study types with the highest medians. It is noteworthy how clinical trials stood out in news mentions and *Mendeley* readers, while the consensus development conferences and guidelines had the highest median values in terms of *altmetric attention score* and *Twitter* mentions. However, it should be noted that the number of clinical trials (1,325) was much higher than that of consensus development conferences and guidelines (143). Another study type that stood out in terms of altmetrics was meta-analyses. Having a median value of 10 in both the *altmetric attention score* and *Twitter* mentions, as well as the third highest median of *Mendeley* readers (75), showed that this study type's social attention is not restricted to a single altmetric source or a specific social community. The altmetric values of meta-analyses followed very similar patterns to those of systematic reviews, the latter being the second type with the best median value in *Mendeley* readers (79). In contrast, there were the case reports, which, although there were many such publications (4,354), had the lowest medians for all altmetrics. Finally, it could be mentioned that meta-analyses and systematic reviews were not only the most cited study types but also had the highest medians in terms of *Twitter* mentions and *Mendeley* readers.

3.2. Statistical differences between the types of studies

Comparisons were then made between the metrics of the seven study types to analyze how the selected metrics performed according to each study type. This comparison was done by means of the Kruskal–Wallis test, resulting in $p < 0.001$; this means that there were significant differences between the metrics of each type of study. The Kruskal–Wallis test confirmed the results observed in Table 1 and Figure 1, as it indicated that altmetrics presented very different values depending on the type of study. A cross-tabulation of coincidences between study type and metrics, collecting the *p*-values of the Mann–Whitney U test, is shown in Table 2. As can be seen, the altmetric indicator that had the most coincidences within the study types was news mentions, whose number of coincidences was 7, followed by *Twitter* mentions, with a total of 5 coincidences. *Mendeley* readers showed the lowest number of matches. Within the study types, the *p*-values of consensus development conferences and guidelines were found to match for at least five study types. It was followed by the systematic reviews and observational studies, each having coincidences with another four study types, including the grouping of both. It is noteworthy that the systematic review and meta-analysis groups had the same values for *altmetric attention score*, *Twitter* mentions, news mentions, and *Mendeley* readers. This indicate that these types of studies have a relevant role. Finally, the chi-square test of independence was applied. In this hypothesis test, the null hypothesis (H0) was that there would be no relationship between study type and metrics, while the alternative hypothesis (H1) was that there would be a relationship between study type and metrics. The test result was significant ($\chi^2 = 294{,}569.85$; $p < 0.001$).

Table 2. Cross-tabulation of coincidences between altmetric indicators by study type, grouped two by two

	Altmetric attention score	*Twitter* mentions	News mentions	*Mendeley* readers	*Dimensions* citations
Meta-analysis / Systematic review	0.415	0.831	0.932	0.192	–
Meta-analysis / Consensus development	0.229	0.377	0.325	–	–
Clinical trial / Consensus development	0.415	0.990	0.090	–	–
Consensus development / Systematic review	0.182	0.284	0.288	–	–
Observational study / Consensus development	–	–	0.086	0.084	0.814
Clinical trial / Systematic review	–	0.094	–	–	0.137
Consensus development / Review	–	–	–	0.604	0.985
Meta-analysis / Observational study	–	–	0.105	–	–
Observational study / Systematic review	–	–	0.072	–	–
Observational study / Review	–	–	–	–	0.211

4. Discussion and conclusion

In this paper we focused on the altmetrics of COVID-19 studies published in 2021, using the main types of medical studies to analyze the differences between them. The results indicated that altmetrics in health science research, specifically on the COVID-19 research front, may be highly determined by the type of research study; conversely, they suggested that altmetrics can capture the utility of the research explored here. In medicine and especially in evidence-based medicine, the usefulness of academic papers is linked to the evidence of their results and their practical application in the clinical world. One way to visualize utility is through the pyramid of scientific evidence, in which studies are assigned to levels of evidence based on their methodology. The evidence pyramid is an easy way to visualize the most valuable information within this hierarchy of evidence (**Arsenault**, 2022). For example, in Figure 2A we have included a pyramid from the *University of Washington Health Sciences Library* (**Kowalczyk**; **Truluck**, 2013; **Murad** *et al.*, 2016). It can clearly be seen how the types of studies are ordered, with the consensus development conferences and guidelines being on the top. In this way, a pyramid of evidence (Figure 2B) was created using the quantitative data obtained in results; specifically, we have ordered study types using the values of the *altmetric attention score* included in Table 2.

As can be seen, both pyramids are essentially the same, with the main difference being the clinical trials, which are in third place in the *University of Washington* pyramid but in second place in the one produced from the altmetric attention scores. If we compare the results generated quantitatively with altmetrics with other pyramids of evidence generated by specialists (**Arieta-Miranda** *et al.*, 2022; **Murad** *et al.*, 2016), the similarities are more than reasonable. This is explained by the fact that altmetrics capture the social attention that publications receive, so the typologies most closely related to society, at least the most useful ones, are likely to receive more attention on social platforms. For example, consensus development conferences and guidelines are a way to bring together citizens, decision-makers, and an array of experts to address issues of public importance; clinical trials are situated at the peak since their results are highly valid (**Lazcano-Ponce** *et al.*, 2004); and meta-analysis is the statistical process of analyzing and combining results from several similar studies (**Harris** *et al.*, 2014). Reviews (5), in addition to their educational component, are hypothesis generators, which are very important when analyzing a new topic such as COVID-19 (**Valderrama** *et al.*, 2021).

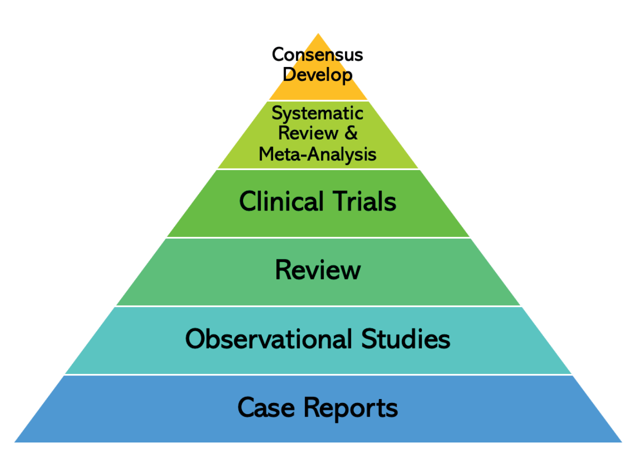

Figure 2A. *University of Washington Health Sciences Library*

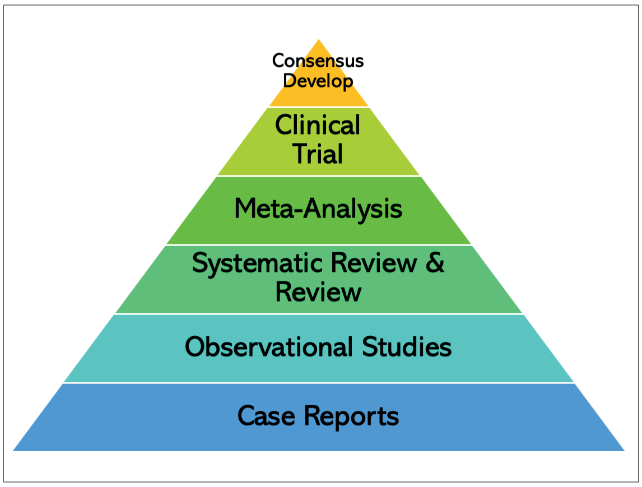

Figure 2B. Pyramid adapted from the value of the *Altmetric attention score* presented in Table 2

We can conclude that, depending on the type of study, altmetrics reach different values and that, in addition, these values are able to capture the usefulness and evidence of the studies, as we have seen when comparing our results with the pyramids of evidence. These are results that provide empirical evidence on the possible meaning of altmetrics and open the doors to their application in evaluative bibliometrics, at least in the field of health sciences. This study is not without limitations. Altmetrics from only three social media outlets were considered; one of these altmetrics was news mentions, which were present in approximately one-third of the publications studied. Similarly, despite a high volume of COVID-19 publications, only a single year's publication period was used. For this reason, future work should explore this relationship between study type and altmetrics in the medical field beyond COVID-19 studies.

5. Note

This study is based on a communication presented at the *STI2022* conference in Granada, Spain, but it has been fully reviewed:
https://doi.org/10.5281/zenodo.6957471

6. References

Arieta-Miranda, Jessica M.; **Ruiz-Yasuda, Catherine C.**; **Pérez-Vargas, Luis-Fernando**; **Torres-Ricse, Dayhanne A.**; **Díaz, Solange-Pérez**; **Arieta, Yosseline-Chávez**; **Victorio, Daniel-José-Blanco**; **Ramos, Gilmer-Torres** (2022). "New pyramid proposal for the levels of scientific evidence according to SIGN". *Plastic and reconstructive surgery*, v. 149, n. 4, pp. 841e-843e.
https://doi.org/10.1097/PRS.0000000000008946

Aristovnik, Aleksander; **Ravšelj, Dejan**; **Umek, Lan** (2020). "A bibliometric analysis of COVID-19 across science and social science research landscape". *Sustainability*, v. 12, n. 21.
https://doi.org/10.3390/su12219132

Arroyo-Machado, Wenceslao; **Torres-Salinas, Daniel**; **Robinson-García, Nicolás** (2021). "Identifying and characterizing social media communities: A socio-semantic network approach to altmetrics". *Scientometrics*, v. 126, n. 11, pp. 9267-9289.
https://doi.org/10.1007/s11192-021-04167-8

Arsenault, Benoit J. (2022). "From the garden to the clinic: How Mendelian randomization is shaping up atherosclerotic cardiovascular disease prevention strategies". *European heart journal*, v. 43, n. 42, pp. 4447-4449.
https://doi.org/10.1093/eurheartj/ehac394

Bhandari, Mohit; **Montori, Victor M.**; **Devereaux, Philip J.**; **Wilczynski, Nancy L.**; **Morgan, Douglas**; **Haynes, R. Brian** (2004). "Doubling the impact: Publication of systematic review articles in orthopaedic journals". *JBJS*, v. 86, n. 5.
https://journals.lww.com/jbjsjournal/Fulltext/2004/05000/Doubling_the_Impact__Publication_of_Systematic.19.aspx

Brainard, Jeffrey (2021). "No revolution: COVID-19 boosted open access, but preprints are only a fraction of pandemic papers". *Science*, 8 Sept.
https://doi.org/10.1126/science.acx9058

Chriscaden, Kimberly (2020). *Impact of COVID-19 on people's livelihoods, their health and our food systems*. World Health Organization.
https://www.who.int/news/item/13-10-2020-impact-of-COVID-19-on-people's-livelihoods-their-health-and-our-food-systems

Colavizza, Giovanni (2020). "COVID-19 research in Wikipedia". *Quantitative science studies*, v. 1, n. 4, pp. 1349-1380.
https://doi.org/10.1162/qss_a_00080

Colavizza, Giovanni; **Costas, Rodrigo**; **Traag, Vincent A.**; **Van-Eck, Nees-Jan**; **Van-Leeuwen, Thed**; **Waltman, Ludo** (2021). "A scientometric overview of CORD-19". *PLoS one*, v. 16, n. 1, e0244839.
https://doi.org/10.1371/journal.pone.0244839

Fassin, Yves (2021). "Research on COVID-19: A disruptive phenomenon for bibliometrics". *Scientometrics*, v. 126, n. 6, pp. 5305-5319.
https://doi.org/10.1007/s11192-021-03989-w

Fraumann, Grisha; **Colavizza, Giovanni** (2022). "The role of blogs and news sites in science communication during the COVID-19 pandemic". *Frontiers in research metrics and analytics*, v. 7.
https://www.frontiersin.org/articles/10.3389/frma.2022.824538

Harris, Joshua D.; **Quatman, Carmen E.**; **Manring, Maurice M.**; **Siston, Robert A.**; **Flanigan, David C.** (2014). "How to write a systematic review". *The American journal of sports medicine*, v. 42, n. 11, pp. 2761-2768.
https://doi.org/10.1177/0363546513497567

Haunschild, Robin; **Bornmann, Lutz** (2021). "Can tweets be used to detect problems early with scientific papers? A case study of three retracted COVID-19/SARS-CoV-2 papers". *Scientometrics*, v. 126, n. 6, pp. 5181-5199.
https://doi.org/10.1007/s11192-021-03962-7

Haustein, Stefanie; **Costas, Rodrigo**; **Larivière, Vincent** (2015). "Characterizing social media metrics of scholarly papers: The effect of document properties and collaboration patterns". *PLoS one*, v. 10, n. 3, e0120495.
https://doi.org/10.1371/journal.pone.0120495

Hayawi, K.; **Shahriar, S.**; **Serhani, M. A.**; **Taleb, I.**; **Mathew, S. S.** (2022). "ANTi-Vax: A novel Twitter dataset for COVID-19 vaccine misinformation detection". *Public health*, v. 203, pp. 23-30.
https://doi.org/10.1016/j.puhe.2021.11.022

Jung, Richard G.; **Di-Santo, Pietro**; **Clifford, Cole**; **Prosperi-Porta, Graeme**; **Skanes, Stephanie**; **Hung, Annie**; **Parlow, Simon**; **Visintini, Sarah**; **Ramírez, F. Daniel**; **Simard, Trevor**; **Hibbert, Benjamin** (2021). "Methodological quality of COVID-19 clinical research". *Nature communications*, v. 12, n. 1, pp. 943.
https://doi.org/10.1038/s41467-021-21220-5

Kousha, Kayvan; **Thelwall, Mike** (2020). "COVID-19 publications: Database coverage, citations, readers, tweets, news, Facebook walls, Reddit posts". *Quantitative science studies*, v. 1, n. 3, pp. 1068-1091.
https://doi.org/10.1162/qss_a_00066

Kowalczyk, Nina; **Truluck, Christina** (2013). "Literature reviews and systematic reviews: What is the difference?". *Radiologic technology*, v. 85, n. 2, pp. 219-222.
http://www.radiologictechnology.org/content/85/2/219.extract

Lazcano-Ponce, Eduardo; **Salazar-Martínez, Eduardo**; **Gutiérrez-Castrellón, Pedro**; **Ángeles-Llerenas, Angélica**; **Hernández-Garduño, Adolfo**; **Viramontes, José-Luis** (2004). "Ensayos clínicos aleatorizados: Variantes, métodos de aleatorización, análisis, consideraciones éticas y regulación". *Salud pública de México*, v. 46, n. 6, pp. 559-584.
https://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0036-36342004000600012

Majumder, Maimuna S.; **Mandl, Kenneth D.** (2020). "Early in the epidemic: Impact of preprints on global discourse about COVID-19 transmissibility". *The lancet global health*, v. 8, n. 5, pp. e627-e630.
https://doi.org/10.1016/S2214-109X(20)30113-3

Marcec, Robert; **Likic, Robert** (2022). "Using Twitter for sentiment analysis towards AstraZeneca/Oxford, Pfizer/BioNTech and Moderna COVID-19 vaccines". *Postgraduate medical journal*, v. 98, n. 1161, pp. 544-550.
https://doi.org/10.1136/postgradmedj-2021-140685

Montori, Victor M.; **Wilczynski, Nancy L.**; **Morgan, Douglas**; **Haynes, R. Brian**; *The Hedges Team* (2003). "Systematic reviews: A cross-sectional study of location and citation counts". *BMC medicine*, v. 1, n. 1, article 2.
https://doi.org/10.1186/1741-7015-1-2

Murad, M. Hassan; **Asi, Noor**; **Alsawas, Mouaz**; **Alahdab, Fares** (2016). "New evidence pyramid". *Evidence based medicine*, v. 21, pp. 125-127.
https://doi.org/10.1136/ebmed-2016-110401

Nane, Gabriela F.; **Robinson-García, Nicolás**; **Van-Schalkwyk, François**; **Torres-Salinas, Daniel** (2022). "COVID-19 and the scientific publishing system: Growth, open access and scientific fields". *Scientometrics*, v. 128, pp. 345-362.
https://doi.org/10.1007/s11192-022-04536-x

Odone, Anna; **Salvati, Stefano**; **Bellini, Lorenzo**; **Bucci, Daria**; **Capraro, Michele**; **Gaetti, Giovanni**; **Amerio, Andrea**; **Signorelli, Carlo** (2020). "The runaway science: A bibliometric analysis of the COVID-19 scientific literature". *Acta bio-medica: Atenei Parmensis*, v. 91, n. 9-S, pp. 34-39.
https://doi.org/10.23750/abm.v91i9-S.10121

Okike, Kanu; **Kocher, Mininder S.**; **Torpey, Jennifer L.**; **Nwachukwu, Benedict U.**; **Mehlman, Charles T.**; **Bhandari, Mohit** (2011). "Level of evidence and conflict of interest disclosure associated with higher citation rates in orthopedics". *Journal of clinical epidemiology*, v. 64, n. 3, pp. 331-338.
https://doi.org/10.1016/j.jclinepi.2010.03.019

Patsopoulos, Nikolaos A.; **Analatos, Apostolos A.**; **Ioannidis, John P.** (2005). "Relative citation impact of various study designs in the health sciences". *JAMA*, v. 293, n. 19, pp. 2362.
https://doi.org/10.1001/jama.293.19.2362

Pinho-Gomes, Ana-Catarina; **Peters, Sanne**; **Thompson, Kelly**; **Hockham, Carinna**; **Ripullone, Katherine**; **Woodward, Mark**; **Carcel, Cheryl** (2020). "Where are the women? Gender inequalities in COVID-19 research authorship". *BMJ global health*, v. 5, n. 7, e002922.
https://doi.org/10.1136/bmjgh-2020-002922

Priem, Jason (2014). "Beyond bibliometrics: Harnessing multidimensional indicators of performance". In: Cronin, Blaise; Sugimoto, Cassidy R. (eds.). *Altmetrics in the wild: Using social media to explore scholarly impact*, pp. 263-287). MIT Press.
https://arxiv.org/html/1203.4745

Röhrig, Bernd; **Du-Prel, Jean-Baptist**; **Wachtlin, Daniel**; **Blettner, Maria** (2009). "Types of study in medical research: Part 3 of a series on evaluation of scientific publications". *Deutsches Arzteblatt International*, v. 106, n. 15, pp. 262-268.
https://doi.org/10.3238/arztebl.2009.0262

Torres-Salinas, Daniel (2020). "Ritmo de crecimiento diario de la producción científica sobre COVID-19. Análisis en bases de datos y repositorios en acceso abierto". *Profesional de la información*, v. 29, n. 2, e290215.
https://doi.org/10.3145/epi.2020.mar.15

Torres-Salinas, Daniel; **Robinson-García, Nicolás**; **Castillo-Valdivieso, Pedro A.** (2020). *Open access and altmetrics in the pandemic age: Forecast analysis on COVID-19 literature*. bioRxiv.
https://doi.org/10.1101/2020.04.23.057307

Valderrama, Pilar; **Baca, Pilar**; **Solana, Carmen**; **Ferrer-Luque, Carmen-María** (2021). "Root canal disinfection articles with the highest relative citation ratios. A Bibliometric analysis from 1990 to 2019". *Antibiotics*, v. 10, n. 11, 1412.
https://doi.org/10.3390/antibiotics10111412

Valderrama, Pilar; **Torres-Salinas, Daniel** (2022). "Does the type of study on COVID-19 influence the value of altmetrics?". In: Robinson-García, Nicolás; Torres-Salinas, Daniel; Arroyo-Machado, Wenceslao (eds.). *STI 2022 Conference Proceedings*. Zenodo.
https://doi.org/10.5281/zenodo.6957471

Van-Schalkwyk, François; **Dudek, Jonathan** (2022). "Reporting preprints in the media during the COVID-19 pandemic". *Public understanding of science*, v. 31, n. 5, pp. 608-616.
https://doi.org/10.1177/09636625221077392

Van-Schalkwyk, François; **Dudek, Jonathan**; **Costas, Rodrigo** (2020). "Communities of shared interests and cognitive bridges: The case of the anti-vaccination movement on Twitter". *Scientometrics*, v. 152, n. 2, pp. 1499-1516.
https://doi.org/10.1007/s11192-020-03551-0

Zahedi, Zohreh; **Costas, Rodrigo**; **Wouters, Paul** (2014). "How well developed are altmetrics? A cross-disciplinary analysis of the presence of 'alternative metrics' in scientific publications". *Scientometrics*, v. 101, n. 2, pp. 1491-1513.
https://doi.org/10.1007/s11192-014-1264-0

Zhang, Lin; **Zhao, Wenjing**; **Sun, Beibei**; **Huang, Ying**; **Glänzel, Wolfgang** (2020). "How scientific research reacts to international public health emergencies: A global analysis of response patterns". *Scientometrics*, v. 124, n. 1, pp. 747-773.
https://doi.org/10.1007/s11192-020-03531-4

Zhang, Yi; **Cai, Xiaojing**; **Fry, Caroline V.**; **Wu, Mengjia**; **Wagner, Caroline S.** (2021). "Topic evolution, disruption and resilience in early COVID-19 research". *Scientometrics*, v. 126, n. 5, pp. 4225-4253.
https://doi.org/10.1007/s11192-021-03946-7