What are the variables associated with Altmetric scores?

Amanda Costa Araujo*, Adriane Aver Vanin, Dafne Port Nascimento, Gabrielle Zoldan Gonzalez and Leonardo Oliveira Pena Costa

Abstract

Background: Social media has been used to disseminate the contents of scientific articles. To measure the impact of this, a new tool called Altmetric was created. Altmetric aims to quantify the impact of each article through online media. This systematic review aims to describe the associations between the publishing journal and published article variables and Altmetric scores.

Methods: Searches on MEDLINE, EMBASE, CINAHL, CENTRAL, and Cochrane Library were conducted. We extracted data related to both the publishing article and the publishing journal associated with Altmetric scores. The methodological quality of included articles was analyzed by the Appraisal Tool for Cross-sectional Studies.

Results: A total of 19 articles were considered eligible. These articles summarized a total of 573,842 studies. Citation counts, journal impact factor, access counts, papers published as open access, and press releases generated by the publishing journal were associated with Altmetric scores. The magnitude of these associations ranged from weak to strong.

Conclusion: Citation counts and journal impact factor are the most common variables associated with Altmetric scores. Other variables such as access counts, papers published in open access journals, and the use of press releases are also likely to be associated with online media attention.

Systematic review registration: This review does not contain health-related outcomes. Therefore, it is not eligible for registration.

Keywords: Altmetric, Altmetrics, Social impact, Social media, Methodological review

Background

The most common way to assess the impact of an article is based on the number of citations [1]. The mean number of citations for all articles published in a journal in the preceding 2 years is called the journal’s impact factor [1]. However, the number of citations and the journal’s impact factor do not precisely reflect whether the message of the article is reaching a wider audience [2]. Currently, social media is being used to disseminate the contents of scientific articles [3, 4]. However, until recently, the impact of scientific articles on social media was not quantified. To measure this type of impact, a new score (called Altmetric) was created [3, 4].

Altmetric measures the impact of each article through the attention attracted online [3]. Moreover, the Altmetric score reveals the instantaneous attention attracted online for articles in news outlets, comments on blogs, number of tweets, and mentions on social media. There are two types of Altmetric scores. The Altmetric-mentioned score includes data sources involving social media (e.g., Facebook, Twitter), newspapers, encyclopedias (e.g., Wikipedia), online platforms (e.g., Faculty1000 and publication peer reviews),
videos on YouTube, question-and-answer sites (e.g., Q&A stack overflow), and policy documents in PDF form available over the internet. The Altmetric reader score includes data sources involving reference managers available online (e.g., Mendeley, CiteULike, and Connotea). The Altmetric score can be graphically represented by a “donut.” The different colors of the Altmetric donut represent the number of mentions on each specific online media source. For example, mentions on Twitter are represented in blue (Fig. 1).

Research about Altmetric has been increasing and becoming more popular in recent years [5]. However, most articles about Altmetric published to date are only introductory tutorials or editorials [1, 3, 4, 6, 7]. Patthi et al. [2] published a systematic review in the field of dentistry that aimed to analyze the correlations between journal citations and Altmetric scores. The review concluded that journal citations and Altmetric scores are positively correlated (with Pearson’s $r$ ranging from 0.30 to 0.61).

Recent articles from several research fields [8, 9] showed that the number of article citations and Altmetric score are positively correlated. Finch et al. [10] showed that the number of tweets (i.e., an Altmetric component) could predict citations within the first 3 days of article publication. Araujo et al. [11] found that number of citations and journal’s impact factor were positively associated with Altmetric [11]. These authors also found that the number of years since publication and having a descriptive title (i.e., a title describing the aim of the study but not revealing the main conclusions) were negatively associated with Altmetric [11]. Therefore, it is assumed that the publishing journal and publishing article variables, such as citation counts, journal impact factor, access counts (considered the sum of HTML views and PDF downloads), papers published as open access, time since publication, and press releases generated by the publishing journal, are likely to be associated with Altmetric [11]. This systematic review aims to summarize all available evidence on the associations between the publishing journal and publishing article variables and Altmetric scores.

**Methods**

**Research question**

What publishing journal and publishing article variables are associated with Altmetric scores?

**Search strategy for identification of studies**

Systematic searches were conducted on MEDLINE, EMBASE, CINAHL, CENTRAL, and Cochrane Library, as per the Cochrane Handbook [12], including publications from the inception of these databases until March 31, 2021, without language restrictions. As the topic is novel, we used only two search terms (Altmetric OR Altmetrics) in all databases to ensure a more sensitive search strategy.

**Inclusion and exclusion criteria**

We included any original research studies that measured any type of association between the publishing journal and/or the publishing article with Altmetric scores, such as citation counts (i.e., number of citations), journal impact factor, access counts (considered the sum of HTML views and PDF downloads), papers published as open access, time since publication, and press releases generated by the publishing journal, are likely to be associated with Altmetric [11]. This systematic review aims to summarize all available evidence on the associations between the publishing journal and publishing article variables and Altmetric scores.

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access, time since publication, and press releases generated by the publishing journal. Studies that did not have at least one of these variables were excluded. Letters to the editor, editorials, and conference abstracts were also excluded. Moreover, we excluded articles that included a subset of highly cited papers or with extremely high Altmetric scores.

Data collection
Two review authors (AA and AV) independently screened all studies for eligibility and data extraction. All discrepancies identified during the stages and throughout the review were resolved via discussion or through arbitration provided by another investigator (DN). The study selection process included (1) screening the titles and abstracts and (2) screening of full-text articles.

Data extraction
Two review authors independently extracted the following data: (1) authors, (2) year of publication, (3) research field, (4) sample size of studies analyzed, (5) study design of the included studies, (6) study aims, (7) study results, and (8) study conclusions. Variables about the publishing journal included (9) journal impact factor, (10) access counts (considered the sum of HTML views and PDF downloads), (11) papers published as open access, and (12) press releases generated by the publishing journal. Variables about the publishing articles included (13) citation counts (i.e., number of citations), and (14) time since publication. We also collected data related to (15) the Altmetric mentioned score and (16) the Altmetric reader score. We contacted authors by email to request additional information that was not reported in the original manuscripts.

Ethics and registration
No ethical approval was required for this study. As this review has no health-related outcomes, no registration was needed [13].

Data analysis and quality of studies
Due to a large data heterogeneity, meta-analysis was not possible. For this reason, our results are reported descriptively. The quality criteria of included articles were analyzed using an adapted version of the Appraisal Tool for Cross-sectional Studies (AXIS) [14]. This tool was developed to systematically assess the quality of cross-sectional studies by assessing 20 items. Each item is rated as “yes,” “no,” or “don’t know/no comment” [14]. The AXIS was the tool that best covered the included studies. We adapted the AXIS by excluding items 7 (Were measures undertaken to address and categorize non-responders?), 9 (Were the risk factor and outcome variables measured correctly using instruments/measurements that had been trialed, piloted or published previously?), 13 (Does the response rate raise concerns about non-response bias?), 14 (If appropriate, was information about non-responders described?), and 20 (Was ethical approval or consent of participants attained?), as these items are unrelated to the aims of our review.

Results
Search results
The initial search yielded 1109 potentially eligible studies. After screening by title and abstract and removing duplicates, we considered 42 potentially eligible studies for inclusion and retrieved full-text articles. Nineteen published studies [11, 15–32] met the inclusion criteria and were included in this review. The study flow diagram of the eligibility assessment is presented in Fig. 2.

Quality of studies
We did not consider the total score based on the instructions of the AXIS [14]. However, we observed that the studies included in general did not have good methodological quality (Table 1). We observed that most studies did not select a representative/random sample of a population (item 5), as most studies sampled the articles from main journals in their fields.

Characteristics of included studies
The 19 eligible studies were published between 2014 and 2021 and summarized a total of 573,842 articles. The study designs of the included articles were mixed research designs [15–28, 30–32] and randomized controlled trials [11, 29]. The research fields of these articles included biomedicine [20], burn care [31], ecology and conservation [30], emergency medicine [19], engineering and technology, gastroenterology and hepatology [26], general medicine [18], joint arthroplasty [29], medical education [15], medical and natural sciences [25], multidisciplinary [22], oncology [24], physiotherapy [11, 16], plastic surgery [17], psychiatry [23], radiology [32], rheumatology [21], social sciences and humanities, solid organ transplantation [27], and spine [28]. The main objective of the included studies was to assess the association between Altmetric scores and variables such as citation counts (i.e., number of citations), journal impact factor, access counts (considered the sum of HTML views and PDF downloads), papers published as open access, time since publication, and/or press releases generated by the publishing journal. A summary of the methods, data analysis, results, and conclusions is presented in Table 2.

Statistical analysis and associations of included studies
Different types of analyses were conducted in the included studies: correlation analysis [15, 17–19, 22, 23,
Discussion

We aimed to summarize all available evidence on the associations between the publishing journal and publishing article variables and Altmetric scores. We found that citation counts (i.e., number of citations), journal impact factor, access counts (considered the sum of HTML views and PDF downloads), papers published as open access, time since publication, and press releases generated by the publishing journal were associated with Altmetric scores. The magnitude of these associations ranged from weak to strong. In addition, we observed that citation counts and journal impact factor were associated with Altmetric scores in all included studies [11, 15–32].

There is a previous systematic review about the correlation between citation counts and Altmetric in medical research [2]. Moreover, there are articles that have measured associations between citation counts and Altmetric scores [15, 32]. In accordance with the systematic review [2] and these articles [15, 32], we found a positive correlation between citation counts and Altmetric scores. Similarly, our overview indicated positive associations (ranging from weak to moderate) between citation counts and Altmetric scores [11, 15–32]. These results are similar to those related to a journal’s impact factor [11]. This is not surprising, because a journal’s impact factor is based on citation counts of scientific articles [1]. We also found that most included studies, with the exception of those by Araujo et al. [11, 16] and Knight [27], did not analyze...
Thus, our findings are largely based on the Altmetric-mentioned score. We strongly recommend that further investigations on Altmetric reader score be conducted.

Regarding the quality of studies, the main limitation we observed was the lack of reporting the methods in detail. Items related to sampling, selection criteria, and statistical analysis in general were poorly described. On the other hand, the articles were clear in terms of data analysis and results. Finally, most authors presented the limitations of the study in their discussion and disclosed their potential conflicts of interest.

No studies identified specific characteristics of articles, for example, analysis of studies that published popular/hot topics (e.g., studies on coronavirus, miraculous diets, cancer prevention, early life on earth, religious evidence). Moreover, there is no analysis of studies comparing whether the direction of the results (i.e., positive versus negative conclusions) influences Altmetric scores. These characteristics are likely to increase the number of
Table 2: Summary of the objectives and methods according to the variables of interest in the review and author’s conclusions

| No | Author and year of publication (research field) | Objectives | Methods | Author’s conclusions |
|----|------------------------------------------------|------------|---------|----------------------|
| 1  | Amath et al., 2017 [15] (Medical Education Journals) | To analyze the relationships among Altmetric score, access counts and citation counts. | Year of search strategy: 2012 and 2013. Sample size: n = 482. Data extraction: citation counts, access counts and Altmetric score. | Altmetric scores were weakly correlated with readership (access counts) and impact (citation counts). |
| 2  | Araujo et al., 2018 [11] (Physiotherapy) | To analyze factors related with citation counts, journal impact factor and time since publication with Altmetric score. | Year of search strategy: between 2014 and 2015. Sample size: n = 200. Data extraction: citation counts, journal impact factor, time since publication and Altmetric score. | Researchers should preferably select high impact factor journals for submission. |
| 3  | Araujo et al., 2021 [16] (Physiotherapy) | To analyze factors related with citation counts, journal impact factor, open access and time since publication with Altmetric score. | Year of search strategy: between 2015 and 2017. Sample size: n = 66 systematic reviews. Data extraction: citation counts, journal impact factor, open access, time since publication and Altmetric score. | Researchers should preferably publish their articles in journals with high impact factor (which is indirectly linked to citations). |
| 4  | Assad et al., 2020 [17] (Plastic Surgery) | To analyze the relationship between citation counts and Altmetric score. | Year of search strategy: 2016. Sample size: n = 1420. Data extraction: citation counts and Altmetric score. | Altmetric scores were weakly correlated with citation counts. |
| 5  | Ayoub et al., 2021 [26] (Gastroenterology and Hepatology) | To analyze the relationship between citation counts and Altmetric score. | Year of search strategy: 2014. Sample size: n = 4026. Data extraction: citation counts and Altmetric score. | Altmetric scores were strongly correlated with citation counts. |
| 6  | Barakat et al., 2019 [18] (General Medicine Journals) | To analyze the relationship between citation counts and Altmetric score for high-impact general medicine journals. | Year of search strategy: 2014. Sample size: n = 551. Data extraction: citation counts and Altmetric score. | Altmetric scores were poorly correlated with the number of citations in the subsequent 3 years. |
| 7  | Barbic et al., 2016 [19] (Emergency Medicine) | To analyze the citation counts, journal impact factor and Altmetric scores in emergency medicine journals. | Year of search strategy: 2014. Sample size: n = 50. Data extraction: citation counts, journal impact factor and Altmetric score. | Altmetric scores were weakly correlated with citation counts and journal impact factor. |
| 8  | Bornmann et al., 2018 [20] (Biomedical Area) | To analyze the dimensions of measurement for citation counts and Altmetric. | Year of search strategy: between 2011 and 2013. Sample size: n = 33,683. Data extraction: citation counts and Altmetric score. | Altmetric reader score are associated to citation counts. |
| 9  | Chen et al., 2019 [21] (Rheumatology) | To analyze the relationship between citation counts and Altmetric score. | Year of search strategy: between 2010 and 2015. Sample size: n = 1460. Data extraction: citation counts and Altmetric score. | Disease area did not correlate with Altmetric and citations counts. Altmetric identified different articles as high impact compared with citation metrics. |
| 10 | Costas et al., 2015 [22] (Multidisciplinary) | To analyze the relationship between citation counts, journal impact factor and Altmetric score. | Year of search strategy: 2013. Sample size: n = 500,229. Data extraction: citation counts, journal impact factor and Altmetric score. | Altmetric scores were weakly correlated with citations. This findings suggests that the potential of Altmetric to replace traditional citation analysis is not very strong. |
| 11 | Dagar et al., 2021 [23] (Psychiatry) | To analyze the relationship between citation counts and Altmetric score. | Year of search strategy: 2016. Sample size: n = 360. Data extraction: citation counts and Altmetric score. | Altmetric scores were weakly correlated with citation counts. Besides that, the authors found a very high degree of public engagement with psychiatry research. |
| 12 | Didegah et al., 2018 [25] | To analyze the differences between citation counts and Altmetric score. | Year of search strategy: between 2012 and 2014. | Altmetric reader score are associated to citation counts. |
people who access and share these articles on social media [11]. We recommend that future studies identify if these characteristics are associated with Altmetric scores.

Finally, we propose 4 suggestions to improve the social impact and visibility of scientific articles: (1) select high impact factor journals for submission of articles; (2) use provocative titles (titles expressing the results of the trial) or interrogative titles; (3) use social media (Twitter, Facebook, etc.), websites, and blogs to disseminate principal findings; and (4) post the article with its digital object identifier (DOI) or the journal’s link to the article to be captured by Altmetric. These simple strategies are likely to improve the visibility of articles to a larger readership [5, 33]. The major strength of this study is the inclusion of articles from all fields of the research (n = 565,352 articles analyzed). On the other hand, a possible limitation of this study is the large heterogeneity of the included studies. Because of this, the data were analyzed only descriptively. Another potential limitation of our review is related to the selection of the databases we chose. We decided to cover the most comprehensive databases, such as MEDLINE, CINAHL, EMBASE, Cochrane Library, and CENTRAL, and we might have missed some eligible articles published in smaller databases or gray literature.

Table 2 Summary of the objectives and methods according to the variables of interest in the review and author’s conclusions (Continued)

| No | Author and year of publication (research field) | Objectives | Methods | Author’s conclusions |
|----|-----------------------------------------------|------------|---------|----------------------|
| 13 | Haneef et al., 2017 (Oncology)                | To analyze the variables journal impact factor, press release and open access with Altmetric score of articles evaluating cancer treatments. | Year of search strategy: between August 2011 and July 2012. Sample size: n = 6,979. Data extraction: citation counts and Altmetric score. | The press release and the journal impact factor are the most important factors associated with online media attention were the presence. |
| 14 | Knight, 2014 (Solid Organ Transplantation)    | To analyze the association between citation counts and Altmetric score in the field of solid organ transplantation. | Year of search strategy: first 6 months of 2014. Sample size: n = 13,623. Data extraction: citation counts and Altmetric score. | Altmetric scores were weakly correlated with citation counts. Blogging and expert recommendation, in particular, are associated with higher citation rates. |
| 15 | Kunze et al., 2020 (Joint Arthroplasty)        | To analyze the relationship between citation counts and the Altmetric score. | Year of search strategy: between 2005 and 2015. Sample size: n = 42. Data extraction: citation counts and Altmetric score. | High methodologic quality and limited study bias markedly contribute to the Altmetric of RCTs in the total joint arthroplasty literature. |
| 16 | Lamb et al., 2018 (Ecology and Conservation)   | To analyze the association between citation counts and the Altmetric score. | Year of search strategy: January, February and March 2017. Sample size: n = 380. Data extraction: citation counts and Altmetric score. | There are strong association between science communication (measured by the Altmetric score) and citation counts. |
| 17 | Richardson et al., 2020 (Spine Journals)      | To analyze the relationship between citation counts and the Altmetric score. | Year of search strategy: 2016. Sample size: n = 8,322. Data extraction: citation counts and Altmetric score. | Altmetric scores were weakly correlated with citation counts in seven spine journals. |
| 18 | Richardson et al., 2021 (Spine Journals)      | To analyze the relationship between citation counts and the Altmetric score. | Year of search strategy: 2017. Sample size: n = 285. Data extraction: citation counts and Altmetric score. | Altmetric scores were weakly correlated with citation counts. Besides that, the authors recommend the combined use of Altmetric and traditional metrics such as citation count and impact factor. |
| 19 | Rosenkrantz et al., 2017 (Radiology)          | To analyze citation counts and Altmetric score for articles in popular general radiology journals. | Year of search strategy: 2013. Sample size: n = 892. Data extraction: citation counts and Altmetric score. | Articles published in four popular radiology journals overall received relatively low attention on social media comparison with citations. |
| Studies and analyses | Citation counts | Journal impact factor | Access counts | Open access | Time since publication | Press release |
|---------------------|-----------------|----------------------|--------------|-------------|------------------------|--------------|
| Correlation analysis |                 |                      |              |             |                        |              |
| Amath et al. [15]   | r = 0.25        |                      |              |             | r = 0.30               |              |
| Assad et al. [17]   | r = 0.33        |                      |              |             |                        |              |
| Ayoub et al. [26]   | r = 0.62        |                      |              |             |                        |              |
| Barakat et al. [18] | r = 0.33        |                      |              |             |                        |              |
| Barbic et al. [19]  | r = 0.22        | r = 0.35             |              |             |                        |              |
| Costas et al. [22]  | r = 0.18        |                      |              |             |                        |              |
| Dagar et al. [23]   | r = 0.43        |                      |              |             |                        |              |
| Knight [27]         | r = 0.16* and   |                      |              |             |                        |              |
|                     | r = 0.23**      |                      |              |             |                        |              |
| Kunze et al. [29]   | r = 0.36        |                      |              |             |                        |              |
| Richardson et al. [28] | r = 0.32     |                      |              |             |                        |              |
| Richardson et al. [31] | r = 0.12        |                      |              |             |                        |              |
| Rosenkrantz et al. [32] | r = 0.20        |                      |              |             |                        |              |
| Linear regression analysis |              |                      |              |             |                        |              |
| Chen et al. [21]    | R² = 0.00       |                      |              |             |                        |              |
| Multivariate regression analysis |           |                      |              |             |                        |              |
| Araujo et al. [11]  | β = 5.2* and    | β = 3.4              |              |             | β = −4.9               |              |
|                     | β = 10.1**      |                      |              |             |                        |              |
| Araujo et al. [16]  | β = 2.9* and    | β = 15.36* and       |              |             | β = 0.74* and β = 4.04** | β = −21.99* and β = 18.13** |
|                     | β = 6.37**      | β = −3.21**          |              |             |                        |              |
| Haneef et al. [24]  | RoM = 1.10      | RoM = 1.48           |              |             |                        | RoM = 10.14 |
| Boosted regression trees analysis |         |                      |              |             |                        |              |
| Lamb et al. [30]    | Altmetric scores were strongly associated with citation counts. | |
| Principal component analysis and factor analysis |   |                      |              |             |                        |              |
| Bornmann et al. [20] | Altmetric reader score are associated to citation counts. | |
| Didegah et al. [25] | Altmetric reader score are associated to citation counts. | |

*These numbers represent Altmetric mentioned. **These numbers represent Altmetric reader. r = correlation estimates. RoM = regression coefficients represent the logarithm of ratio of mean. \( \beta = \beta \) coefficient.

### Conclusion

Citation counts, journal impact factor, access counts (considered the sum of HTML views and PDF downloads), papers published as open access, time since publication, and press releases generated by the publishing journal were associated with Altmetric scores.

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Not applicable.

### Authors’ contributions

A.A and A.V collected the data and performed the analysis. L.C supervised the project. A.A, A.V, D.N, G.Z, and L.C wrote the manuscript. The authors read and approved the final manuscript.

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### Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

### Declarations

#### Ethics approval and consent to participate

Not applicable.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare that they have no competing interests.

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