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ORIGINAL ARTICLE

Analysis of the altmetric top 100 articles with the highest altmetric attention scores in medical imaging journals

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Abstract

Purpose Alternative metrics (altmetrics) provides a complementary measure of the impact of scientific articles. The aim of this study was to identify and characterize the top 100 articles with the highest Altmetric attention score (AAS) in medical imaging journals.

Materials and methods We searched for AASs articles published in 116 journals in the subject category "Radiology, Nuclear Medicine and Medical Imaging" using the Web of Science. We determined the top 100 articles with the highest AAS using the Altmetric.com database, and then analyzed them with regard to the publishing journal, year, country of origin, type of article, subspecialty, main topic, and imaging technique.

Results The top 100 articles were published in 18 imaging journals, led by Radiology (47%). These articles were published from 2016 to 2018 (94%). Most of the articles were from the United States (62%) and were original clinical studies (59%). The most common subspecialties and imaging technique of study were neuroimaging (30%) and MRI (35%). The main topics of articles were brain disease and function (30%).

Conclusion Our study presents a detailed list and analysis of the top 100 articles with the highest AAS in imaging literature, which provides unique characteristics representing the public's attention in this field.

Keywords Bibliometrics · Medical imaging · Social media · Publication

Abbreviations

AAS	Altmetric attention score
CT	Computed tomography
MRI	Magnetic resonance imaging
PET	Positron emission tomography

Introduction

A recent trend in biomedical literature is to assess the impact of articles in a particular field or journal [1]. Accurate measurement of such impacts is important for evaluating the performance of individual researchers and the quality of academic journals, and identifying the most meaningful research within a field. However, the optimal bibliometric indicator for assessing research impact has not been established [2].

The number of citations is most widely used to measure the scientific impact of individual research articles within a given field [2]. However, traditional citation analysis has been criticized, because it requires a significant duration of time after publication and essentially reflects only the academic impact among researchers in the same field [3].

In comparison to traditional citation metrics, alternative metrics (altmetrics) quantify the dissemination of an article using views on a number of different websites and blogs as well as mentions and posts on social media networks such as Facebook, Twitter, Wikipedia, Mendeley (an online reference management and sharing portal), policy documents, and traditional media sharing of an article [4]. With the recent advent of social media, altmetrics may provide a complementary measure of the impact of articles compared

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to citation counts, particularly outside the academic community [4–6].

To date, a limited number of studies have been conducted to identify top altmetric articles in specific medical fields such as dentistry [7], emergency medicine [8], neurosurgery [9], neurointervention [10], neuroimaging [11], and central nervous system inflammatory demyelinating disease [12]. The aim of this study, therefore, was to identify and characterize the altmetric top 100 articles (those that received the highest Altmetric attention scores [AASs]) in medical imaging journals.

Materials and methods

Our study was a retrospective bibliometric analysis that did not involve human subjects and thus did not require the approval of an institutional review board.

We identified 127 journals listed under the subject category "Radiology, Nuclear Medicine and Medical Imaging" on the Web of Science (Clarivate Analytics, Philadelphia, PA, USA) for the year 2016. After excluding 11 journals that dealt exclusively with radiation oncology ($n=7$), physics ($n=2$), and optic science ($n=2$), we included a total of 116 journals in our study. The top 100 articles with the highest AAS were collected in the Altmetric.com database. We searched the AAS of all articles published in 116 medical imaging journals using "Advanced Search" in Altmetric Explorer (altmetric.com/explorer, Altmetric LLP, London, UK). The site was accessed during 1 day (May 25, 2018) to avoid changes in the articles' scores. The AASs of all articles were recorded, compiled into a single database, and then ranked in descending order based on AAS. No restrictions were placed on the type of article, language, or scholarly identifiers.

Altmetric.com, one of the main providers of alternative indicators, was chosen for the purpose of the study, because it is the most comprehensive source covering the online media activity associated with scientific papers. The database contains more than almost 21 Mio. research articles and captures real-time mentions in public policy documents, blogs, main-stream media from more than 2000 outlets worldwide, online reference managers such as Mendeley, research highlights, postpublication peer review platforms, Open Syllabus, YouTube, and social media networks including Facebook and Twitter. Altmetric.com provides the AAS to measure the overall level of online impact arising from a particular research output, which is presented as a whole number. The AAS is a weighted score of total mentions of the article across various online media, reflecting the anticipated relative degrees of influence of sources on potential readers (e.g., default weights of eight for news outlets, five for science blogs, three for Wikipedia or policy documents, one for Twitter, and 0.25 for Facebook) [4]. Therefore, news outlets contribute to the AAS eight times more to than Twitter and 32 times more than Facebook. This is based on the assumption that newspapers with worldwide readership are likely to generate more attention than do other sources.

We reviewed the full text of articles and extracted the following information according to their specific characteristics: (1) AAS; (2) publishing journal; (3) year of publication; (4) country of origin; (5) type of article (original article [clinical or basic], review, guideline, systematic review/meta-analysis, abstract, miscellaneous [i.e., not conforming to one of the categories listed]); (6) subspecialty (abdominal imaging, breast imaging, cardiac imaging, genitourinary imaging, head and neck imaging, musculoskeletal imaging, neuroimaging, pediatric imaging, thoracic imaging, vascular and interventional radiology, or miscellaneous [i.e., not conforming to one of the categories listed]); (7) main topic; and (8) imaging technique (angiography, computed tomography [CT], conventional radiography, magnetic resonance imaging [MRI], mammography, positron emission tomography [PET], scintigraphy, sonography, spectroscopy, mixed [i.e., more than one radiologic technique used], or none). The country of origin was defined by the authors' address. If the authors were affiliated with more than one country, it was classified as an international collaboration.

Two reviewers (radiologists with 21 and 4 years' experience, respectively) independently analyzed the characteristics of the articles. In cases of disagreement, a third reviewer (a radiologist with 26 years' experience) was included in the discussion until a consensus was reached.

The present study adopted a descriptive research approach by means of bibliometric analysis.

Results

The Supplemental Table lists the top 100 articles with the highest AAS (the two articles ranked 99th had the same AAS) in descending order according to their AASs obtained from the Altmetric.com database at the time of the analysis. The AAS of the 100 articles ranged from 368 to 1469 (mean 516.6 ± 177.6; median 467). The highest scoring article was the 2016 paper by Soares de Oliveira-Szejnfeld et al., "Congenital brain abnormalities and Zika virus: what the radiologist can expect to see prenatally and postnatally," in *Radiology* [13].

The top 100 articles with the highest AAS were published in 18 journals, led by *Radiology* (47%) and followed by *The Journal of the American College of Radiology* (15%) (Table 1). These articles were published from 2005 to 2018, with 94% published in 2016–2018 (Table 2). The 100 articles originated from ten different countries. The majority of the articles came from the United States (62%), distantly followed

Table 1 Top 100 articles with the highest altmetric attention scores ranked by Journal Publication

Journal	No. of articles
Radiology	47
Journal of the American College of Radiology	15
NeuroImage	9
Molecular Imaging & Biology	5
Journal of Nuclear Cardiology	4
Journal of Vascular and Interventional Radiology	4
Journal of Ultrasound in Medicine	3
American Journal of Roentgenology	2
European Journal of Radiology	2
Acta Radiologica	1
American Journal of Neuroradiology	1
Der Radiologe	1
European Radiology	1
Investigative Radiology	1
Journal of Digital Imaging	1
Journal of Nuclear Medicine	1
Journal of Thoracic Imaging	1
Ultrasonics	1

Table 2 Top 100 articles with the highest altmetric attention scores in medical imaging literature according to publication year

Year	No. of articles
2018	22
2017	48
2016	24
2015	2
2014	1
2013	1
2011	1
2005	1

by international collaboration (14%), and The Netherlands (6%) (Table 3). In terms of article type, original clinical studies comprised 59% of the top 100 articles, of which 16% were reviews and 8% were guidelines, and the most common subspecialties of study were neuroimaging (30%) and breast imaging (18%). The most common topics were brain disease and function (30%), followed by malignant tumor (18%), and MRI was the most commonly used imaging technique (35%), which increased to 40% when including mixed techniques (MRI and other techniques) (Table 4).

Discussion

With the increasing use of the Internet and social media, interest in altmetrics has grown rapidly since the concept was first introduced in 2011 [14]. This study is the first of its kind to identify and characterize the top articles with the highest AAS in medical imaging journals. It was interesting that the number one article described the imaging of congenital brain abnormalities associated with Zika virus infection. Previously, the disease was limited to sporadic viral illness transmitted by mosquitoes in Africa and Asia, but a large outbreak of Zika virus disease has been recorded in Central and South America, including Brazil in 2015. The Zika virus infection in pregnant women may result in congenital Zika syndrome, which includes microcephaly and other congenital brain abnormalities [13]. The 2016 Summer Olympics was held in August 2016 in Rio de Janeiro, Brazil. The increasing public awareness of neurological complications of a Zika virus infection in a fetus, propelled by the spread of Olympic news from Brazil through popular and social media, may be the reason for increased public engagement in research for Zika virus infections.

Table 3 Top 100 articles with the highest altmetric attention scores in medical imaging literature according to country of origin

Country	No. of articles
The United States	62
The Netherlands	6
China	4
Germany	3
Japan	3
The United Kingdom	2
Italy	2
Korea	2
Brazil	1
Switzerland	1
International collaboration	14

The top-ranked article in our study had an AAS of 1469, the 50th ranked article had a score of 468, and the 100th a score of 368. These scores were definitely higher than those for neurosurgery (AASs for top 100: 45–643) [9] and emergency medicine (AASs for top 50: 3–176) [8]. Citation rates differ for each specialty and might depend on the size of the scientific community. In contrast, altmetrics may depend not only on the size of the research field but also on interest from the general population. However, the higher score of medical imaging articles in our list might reflect the fact that we searched for articles from 116 journals, whereas previous studies were limited to 18 neurosurgical journals and ten emergency journals [8, 9].

In 2013, Brinjikji et al. performed a bibliometric analysis of the 100 most-cited articles in the field of medical imaging [15]. Although a direct comparison is limited because of differences in time of data collection, we observed varying trends in the top altmetric articles compared to the top-cited ones.

Table 4 Top 100 articles with the highest altmetric attention scores in medical imaging literature according to article type, subspecialty, topic, and imaging technique

	No. of articles
Article type	
Original article	60
Clinical	59
Basic	1
Review	16
Guideline	8
Systematic review/meta-analysis	4
Abstract	2
Miscellaneous	10
Subspecialty	
Neuroimaging	30
Breast imaging	18
Cardiac imaging	10
Thoracic imaging	8
Genitourinary imaging	4
Abdominal imaging	3
Musculoskeletal imaging	3
Vascular and interventional radiology	3
Head and neck imaging	1
Miscellaneous	20
Scintigraphy	2
Conventional radiography	1
Spectroscopy	1
Mixed	10
None	23
Topic	
Brain disease and function	30
Malignant tumor	18
Breast cancer	10
Lung and pleural cancer	5
Liver cancer	2
Prostate cancer	1
Cardiovascular disease	11
Breast imaging	8
Joint disease	3
Pulmonary embolism	2
Radiation	2
Miscellaneous	26
Imaging technique	
Magnetic resonance imaging	35
Mammography	8
Sonography	5
Computed tomography	4
Molecular imaging	4
Positron emission tomography	4
Angiography	3
Scintigraphy	2
Conventional radiography	1
Spectroscopy	1
Mixed	10
None	23

Our analysis indicated that 47% of the altmetric top articles were published in *Radiology*. In Brinjikji's study, the top four basic medical imaging journals (*NeuroImage*, *Magnetic Resonance in Medicine*, *Human Brain Mapping*, and *IEEE Transactions on Medical Imaging*) contributed 56% of the top-cited articles; only 15% of articles were published in *Radiology* [15]. In addition, with regard to the type of articles, our analysis showed that original clinical imaging studies accounted for 59% of the altmetric top articles, which contrasts with Brinjikji et al., who reported that 75% of the top-cited articles were preclinical studies [15]. These discrepancies indicate that clinical studies appearing in a high-impact clinical medical imaging journal receive more interest from the public than do preclinical studies published in a basic imaging journal. The most likely explanation might be that the general public is more interested in common clinical medicine topics than in complex, basic issues.

A large proportion of medical journals use social media platforms such as Facebook and Twitter to expand the reach of scientific publications to parties within and outside the academic community [16]. The use of social media has a great effect on a journal's impact factor and altmetric measures [17, 18]. Journal editors and publishers may have to consider nontraditional methods to expand journal readership and increase the influence of research articles.

Our study found that the altmetric top articles were newly published works; 94% of the articles were published in 2016–2018. In contrast, Brinjikji et al. reported that 70% of the top-cited articles were published before 2000 [15]. This finding emphasizes that altmetrics is particularly sensitive to recent news and that more recent publications receive higher AASs.

Our study also showed that 62% of the altmetric top articles originated from academic institutions in the US, which is in agreement with, though slightly higher than, the findings of Brinjikji et al. (46%) [15]. These US dominance in both citation and altmetric measures can be explained by the large size of the US Scientific Community and its abundant financial resources in research related to medical imaging [19]. The predominance of original articles, recent publications, and authors from the US in our results are in line with previous studies of top altmetric articles in other fields [7–12].

Last, the most common subspecialty was neuroimaging (30%) and the most common imaging technique used

Table 5 Comparison of the most representative altmetric providers

	Altmetric	PlumX	Crossref event data	Impactstory	Article-level metrics-PLoS
Created time	2011	2012	2016	2011	2009
Website	https://www.altmetric.com	https://www.plumanalytics.com	https://www.crossref.org	https://www.impactstory.org	Plos.org/article-level-metrics
Data source	News outlets Blogs Wikipedia pages Policy Documents Patents Twitter Sina Weibo F1000/Publons/Pubpeer Open Syllabus Google+ LinkedIn Facebook Q & A Video/YouTube Reddit/Pinterest	Citation (Scopus) Usage (clicks, downloads, views, library holdings, video plays) Captures (bookmarks, code forks, favorites, readers, watchers) Mentions (blog posts, comments, reviews, Wikipedia references, news media) Social media (Twitter, Facebook)	Cambia Lens Crossref Metadata DataCite Metadata F1000Prime Hypothes.is Newsfeed Reddit Reddit Links Stack Exchange Network Twitter Wikipedia Wordpress.com	Altmetric BASE Mendeley CrossRef ORCID Twitter	Viewed (PLOS Journals, PubMed Central) Saved (CiteULike, Mendeley) Cited (CrossRef, Datacite, Europe PMC, PubMed Central, Scopus, Web of Science) Recommended (F2000 Prime) Discussed (PLOS Comments, Facebook, Reddit, Twitter, Wikipedia)
Accessibility	Annual subscription basis	Particular institutions	Free access	Free access	Free access

was MRI (35%) among the altmetric top articles in medical imaging journals. These trends are similar to those at observed in the previous citation classic study. In Brinjikji's study, however, 58% of the top-cited articles were published in the field of neuroimaging, and 69% used MRI as an imaging modality [15]. These lower concentrations in altmetric top articles may be due to larger and more diverse audiences who use online media to follow the medical imaging literatures, rather than researchers in the same field.

Several previous studies have examined the relationship between traditional citation rates and altmetric scores for scientific papers and have shown very weak correlations between citation and altmetric measures [6, 8, 20–22]. These low correlations indicate that altmetrics are independent of citation metrics and thus can be used as an alternative measure of research impact. The number of citations can reasonably be used to assess the academic influence of a scholarly article on scientists. Altmetrics, however, appears to reflect the disseminative impact based on the interest of lay people rather than scientific merits [4]. There might be a necessity for a new more reliable indicator to measure both scholarly impact within scientific community and interest to the general population. Nonetheless, a more holistic assessment of research impact can be accomplished by combining citation metrics and altmetrics.

A large proportion of physicians are using nontraditional methods such as Twitter, blogs, and podcasts to complement their postgraduate medical education. A recent study reported a much greater dissemination of scientific material on a radiology blog than a peer-reviewed publication, indicating the value of social media for enhancing the impact of new research [23]. Thus, researchers in the medical imaging field are encouraged to embrace social media for directly interacting with a vast scientific and public audience, disseminating new research rapidly, and enhancing the impact of their work. In addition, the Altmetric scoring system may be a useful tool in tracking the reach of publications through various social media channels.

Altmetrics has inherent shortcomings that should be considered. Altmetrics does not cover the demographics of people who mention online research material (professional or public) or the nature (positive or negative) and weight (simple mention or in-depth discussion) of each mention. Furthermore, it may be difficult to assess the credibility of commentators and the validity of their comments in online media because of the anonymity afforded by the internet [24–26].

The present study has some potential limitations. First, we limited our analysis to articles published in medical imaging journals; therefore, some highly influential articles in the fields of radiology and nuclear medicine that were originally published in general medical or other specialty journals may have been excluded from our list. Second, we used only data supplied by Altmetric.com for assessing the top articles. Other tools such as PlumX, Crossref Event Data, Impactstory, Article-Level Metrics-PLoS provide alternative metrics that use different online sources and algorithms, which may offer different results [27, 28] (Table 5).

In conclusion, our study presents a detailed list and analysis of the altmetric top 100 articles published in medical imaging journals, which provides unique characteristics representing the public's attention in this field. The altmetric

top imaging articles were most often recent and original clinical studies.

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Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

Ethical approval All applicable institutional and/or national guidelines for the care and use of animals were followed.

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