

Altmetric vs. Citations: An In-Depth Analysis of Top-tier Cancer Research

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Abstract

In this study, we aimed to comprehensively analyze the altmetric indices of 1000 highly cited articles in the field of cancer, considering the growing importance of social media-based indicators as complementary tools alongside traditional bibliometric indicators for evaluating scientific outputs. Cancer research is a critical area in the medical community, being the second leading cause of death after cardiovascular diseases (CVDs). Conducted as a cross-sectional descriptive study, the bibliographic information of the research sample was obtained from the Scopus citation database. Data about the social media presence and altmetric attention scores (AAS) of each article were collected from the journal and altmetric.com. Subsequently, Excel and SPSS software were employed for analysis. Among the reviewed articles, 96.3% were shared on social media at least once, with Mendeley (99.6%), Patents (86.3%), and CiteULike (66.3%) being the most commonly used altmetric sources. The article titled "Dermatologist-level classification of skin cancer with deep neural networks," published in the Nature journal, obtained the highest AAS of 2864. Additionally, the majority of tweeters and readers were from the USA. Tweeters were predominantly members of the public, while readers were primarily professionals in medicine and dentistry, including PhD students. Spearman tests indicated a statistically significant moderate correlation between AASs and citations ($r= 0.283$, $p\text{-value} < 0.001$). Similarly, a significant weak correlation was observed between the journals' Impact Factor (IF) ($r= 0.217$) and CiteScore ($r= 0.133$) with the number of citations ($p\text{-value} < 0.001$). The findings of this study emphasize the positive impact of social media-based indicators on the number of citations received by scientific articles, making them valuable complementary measures alongside traditional citation indicators for evaluating research impact. We recommend that journals, authors, and researchers actively use social media platforms to enhance the visibility of their work and attract more citations.

Keywords: Scientometrics, Research Evaluation, Citation, Altmetrics, Social Media, Cancer Research.

Introduction

The undeniable ubiquity of social media in modern life has had a significant impact. In recent years, due to the rapid and widespread expansion of Web 2.0 and social networks, many changes have occurred in the way research is conducted and written, scientific findings are disseminated, and scientific communication is established (Chang, Desai & Gosain, 2019; Tokar et al., 2012; Yu, Xu, Xiao, Hemminger & Yang, 2017). In other words, the scholarly publishing industry has been transformed by the internet into a social web, allowing for rapid dissemination and monitoring of research data. This has created new perspectives on evaluating academic outputs (Priem, Piwowar & Hemminger, 2012; Tornberg et al., 2023).

Given the large number of researchers and research studies in various scientific fields, coupled with their strong desire to share and disseminate scientific and technological findings on social media platforms available on the web, alternative metrics have been proposed to evaluate the impact of scientific and technological outputs. Researchers use citation analysis, also known as bibliometric analysis, to identify the most valuable publications in their fields (Ahmadian, Mokhtari, Ghafari & Saberi, 2021; Efron, Jones, Morgan & Nichols, 2022; Hao et al., 2021; Yi et al., 2022). But these traditional methods have their limitations (Benjaminsen et al., 2019; Masic, 2013; Wang, 2013), and as a result, alternative metrics is increasingly being used as a supplement to assess the effects of scientific and technological outputs (Chang et al., 2019; Moradi & Alipour, 2017). Altmetrics refer to alternative measures designed to evaluate the online interactions related to research, such as mentions on social media, blogs, or bookmarks (Navidi & Mansourian, 2015). These alternative criteria are used to measure the social impact of research outputs that cannot be assessed using traditional methods (Cho, 2017; Grover, Elwood, Patel, Ananthb & Brandt, 2022).

Altmetrics offers several features and capabilities that traditional metrics, such as citation counts and impact factors, lack. They allow us to explore new perspectives on impact that were previously difficult to measure, as well as assess the breadth of audiences and diversity of media and online platforms (Gamble, Traynor, Gruzd, Mai, Dormuth & Sketris, 2020). Altmetrics also enables us to review a wide range of information sources, measure the effectiveness of researchers, and improve the evaluation of articles without relying on commercial databases or language restrictions. Furthermore, they allow us to measure impact before publication, speed up the evaluation process through the mass of bookmarks and blogs, and predict impact in the future. Another advantage of altmetrics is that they can measure the impact of non-cited articles, as well as the impact of scientific works and subject areas with low or delayed citations (Erfanmanesh, 2017; Floyd, Wiley, Boyd & Roth, 2021). In contrast to citation, which examines the performance of documents in a qualitatively controlled environment, altmetrics indicators include any informal use and reference to scientific productions in various social media (Nip & Feng, 2022).

The issues discussed above highlight the need for complementary measures to evaluate the impact of scientific publications and interactions on the social web, particularly in the field of cancer. Cancer has been a major public health concern for years, affecting a large number of people and being the second leading cause of death worldwide after CVDs (Nagai & Kim, 2017; Siegel, Miller, Fuchs & Jemal, 2022). The genetic, epigenetic, and environmental complexities of this disease, as well as the tissue, tumour, and cellular variations, can result in inappropriate treatments and significantly reduce the quality of life of affected individuals (The Genetics of Cancer, 2023; Lu, Chan, Tan, Li, Wang & Feng, 2020).

Many altmetric studies have been conducted in various fields of medical sciences, including the most relevant ones: To know which studies in the field of breast cancer have attracted the most attention from the public, a study was conducted using altmetrics. In this study, the New England Journal of Medicine published the articles with the highest AAS, and the correlation between AAS and citation was not significant. They found that the AAS appears to be a reliable assessment of public perception of breast cancer. Combining altmetrics and traditional measures provides a more accurate description of the output of scientific research (Bayar & Peksöz, 2022). Another study to measure the relationship between citation and AAS in the field of gastric cancer. The USA had the highest scientific contribution to this field. The statistical analysis revealed a positive correlation between the AAS and the number of citations, indicating that higher AAS tended to correspond to more citations. The authors concluded that both citation and AAS offer valuable insights, but they provide different perspectives on the impact and public attention received by research articles in the field of gastric cancer (Goksoy & Bozkurt, 2020). Also, in a study focusing on online attention in the field of oral cancer, it was observed that articles in this domain garnered more discussions on platforms like Facebook, Twitter, Mendeley, and news outlets. Most of these articles originated from the USA and the UK. An intriguing finding was that journals with a presence on social media had significantly higher AAS for their articles compared to those without such accounts. However, no significant relationship was reported between the AAS of an article and the ranking of the journal or the number of citations it received. The researchers noted that, from the perspective of the general public, the perceived generalizability of research and its potential real-world applications seemed to carry more weight than the scientific importance or the level of scientific evidence provided by the study itself (Hassona, Qutachi, Dardas, Alrashdan & Sawair, 2019).

So, given the importance of cancer research and the need for effective communication and dissemination of its findings, evaluating altmetrics indicators in this field can provide valuable insights for the researcher and writer community. This analysis can help identify the most influential articles for a diverse public audience and promote their active participation in the field. Therefore, this study aims to analyze the altmetrics indices of the 1000 most cited articles in the field of cancer in the Scopus database. This study will serve as a model for evaluating the impact of cancer research using complementary measures and can inform future research and communication strategies.

Materials and Methods

This study employs a cross-sectional descriptive analysis, utilizing web-based altmetric indicators, to examine a sample of 1000 cancer-related publications. Data collection was conducted manually, starting with the automatic extraction of bibliographic information from the Scopus database in CSV format. The bibliographic information included the publication title, authors, year of publication, and number of citations. Altmetric data was then collected from altmetric.com. This institute was founded by Euan Adie in 2011. The Altmetric indicators extracted from the website provide a range of data points on the social media and online attention received by each publication in the sample, including mentions on Blogs, Twitter, Facebook, News Outlets, and other online sources.

Altmetric users now include some journals, funders, and leading companies in the world (Altmetrics, 2023). The Altmetric Institution uses link recognition and text mining techniques to collect altmetrics data. The underlying principle is that any discussion in Blogs and News,

mentions on Facebook and Twitter, citation in Wikipedia, readership, and bookmarking in Mendeley, CiteULike, and Connotea have different scores. An overall AAS is given based on the total scores, indicating the amount of sharing and use of that article in social media. Therefore, the AAS of a scientific article is based on these resources, reflecting the quantity and quality of attention received by a document on social media (Bornmann, 2014). The Altmetric Donut and AAS were created to simplify the assessment of the amount and nature of attention received by a specific research output (Altmetric, 2023).

The AAS of a publication is standardized based on the number of publications in the same journal and the number of publications published in the same year. This allows for comparison of the AAS of a publication with other articles of the same age or published in the same journal. The Altmetric Institution also provides additional useful statistics on the geographic location, professional status, and discipline of the individuals who are sharing or reading the publication. It is important to note that the Altmetric Institution only provides information on scientific documents that have a Digital Object Identifier (DOI), a PubMed Record ID (PMID), an Archive Identifier (ArXiv ID), or other standard identifiers (Erfanmanesh, 2017).

First, related records were retrieved in April 2021 using the keywords "cancer", "neoplasms", and "tumor" in the title field and limited to original and review articles. Then, they were sorted in the order of citations from the most to the least by using the Cited by (highest) option. No restrictions were applied regarding language or date. Any publication discussing any topic about cancer was included. Finally, the records were reviewed and checked by two separate researchers in terms of the title and, if necessary, the abstract and full text. This was done to ensure that unrelated records were not included in the study. In the case of unrelated articles, this process continued until 1000 titles were reached. Then the Altmetric Bookmarklet tool was used to collect altmetric data. This tool is free and stored as a bookmark in web browsers. The researchers manually searched for the publications on Google and then collected their social media data by referring to the article page on the journal website and the Altmetric Institute. For each publication, the researchers used this tool to gather information about its presence on various social media platforms and entered the data into an Excel file. The data were then analyzed using Excel and SPSS software. Also, the correlation between the variables was examined using Spearman's correlation coefficient. The correlation coefficient r was used to determine the strength of the relationship. When the r value is less than 0.250, the correlation is considered weak. If it falls between 0.250 and 0.499, it's a moderate correlation. A range of 0.500 to 0.749 indicates a strong correlation, while a value of 0.750 or greater signifies a very strong correlation (He et al., 2023; Kocyigit & Akyol, 2021).

Results

A study of cancer publications found that 96.3% of 1000 highly cited articles were mentioned at least once on social media. Table 1 displays the distribution of these publications across various social media platforms.

Table 1

Top ten used altmetric sources of highly cited publications in the field of cancer

SOA	SP	PWAS (%)	TAE	MEPP	HE
Readers on Mendeley	1000	996 (99.6)	896179	899.77	919
Patents	1000	863 (86.3)	26748	30.99	1147
Readers on CiteULike	1000	663 (66.3)	3471	5.23	91
Tweeters	1000	604 (60.4)	23241	38.47	2039
Policy Sources	1000	548 (54.8)	1176	2.14	13
Wikipedia Pages	1000	484 (48.4)	968	2	25
News Outlets	1000	461 (46.1)	4050	8.78	169
Blogs	1000	459 (45.9)	1642	3.57	117
Readers on Connotea	1000	399 (39.9)	1098	2.75	27
Facebook Pages	1000	301 (30.1)	1357	4.50	53

SOA: Sources of Attention; SP: Studied Publications; PWAS: Publication with Altmetric Source; TAE: Total Altmetric Events; MEPP: Mean Events Per Publication; HE: Highest Events

As shown in Table 1, Mendeley was the most commonly used altmetric source for the highly cited publications in the field of cancer, with 99.6% of the publications having at least one reader on the platform. Patents and CiteULike were ranked second and third, with 86.3% and 66.3% of the publications having a presence on these social media tools, respectively. After examining the presence of publications in Mendeley, it was found that these publications were collectively read 896179 times, resulting in an average of 899.77 readers per publication. The most-read article, titled “Improvements in survival and clinical benefit with gemcitabine as first-line therapy for patients with advanced pancreas cancer: a randomized trial”, had 919 readers. This article, published in the Journal of Clinical Oncology in 1997 by Burris, H.A. et al., compared gemcitabine and 5-fluorouracil (5-FU) in treating advanced pancreatic cancer. Gemcitabine showed a significant improvement in symptoms, with a clinical benefit response of 23.8%, compared to 4.8% for 5-FU. Gemcitabine also led to a longer median survival (5.65 months) and a higher 12-month survival rate (18%) compared to 5-FU. Altmetric data indicated that 863 articles (86.3%) in the field of cancer were shared on patents, with a total of 26748 views. The average number of views per publication was 30.99. The most viewed article was titled “Molecular classification of cancer: class discovery and class prediction by gene expression monitoring”, which was published in the Science in 1999 by Golub T.R. et al, and had a total of 1147 views, introduces a gene expression-based approach for cancer classification, successfully identifying and distinguishing between acute myeloid leukemia (AML) and acute lymphoblastic leukemia (ALL) without prior knowledge. After examining the presence of publications in CiteULike, it was found that 663 publications (66.3%) were shared on this platform. The article titled “Hallmarks of cancer: the next generation” had 3471 views and an average of 5.23 citations. This article, published in the Cell and written by Hanahan D. and Weinberg R.A., discusses cancer hallmarks pivotal in tumor development, including sustaining proliferative signaling, evading growth suppressors, resisting cell death, enabling replicative immortality, inducing angiogenesis, and activating invasion and metastasis.

The altmetric bookmarklet provides interesting information about tweeters and readers based on the information available in the user profile. In total, readers from more than 90 countries have tweeted and read the most cited publications on Twitter and Mendeley. Table 2 lists the top ten countries by name. As shown, the highest number of tweeters were from the USA (5931), the UK (1241), and Spain (981). Also, results for readers from Mendeley showed that the highest number of readers were from the USA (11569), followed by the UK (4839) and Germany (2910), respectively.

Table 2

Top ten countries of tweeters and readers of highly cited publications in the field of cancer

Country	Tweeters	Country	Readers
USA	5931	USA	11569
UK	1241	UK	4839
Spain	981	Germany	2910
Japan	884	Spain	2253
Canada	613	Brazil	1875
France	417	Japan	1655
Australia	415	Canada	1558
Mexico	236	France	1368
South Africa	209	Netherlands	1053
Germany	208	India	1043

Table 3 provides information on the membership type of tweeters, the professional status, and the discipline of readers. According to the data presented, the majority of tweeters were public members (15504). Scientists (3912) were ranked second, followed by practitioners such as doctors and other healthcare professionals (2743). Concerning the professional status of the readers of the most cited publications, the majority were PhD students (200464), followed by researchers (160291) and master students (132881). In terms of disciplines, most readers were medicine and dentistry (257874), agricultural and biological sciences (251495), and biochemistry, genetics, and molecular biology (140170).

Table 3

Characteristics of tweeters and readers of highly cited publications in the field of cancer

Tweeters By Type of Membership	Count
Members of the Public	15504
Scientists	3912
Practitioners (doctors, other healthcare professionals)	2743
Science communicators (journalists, bloggers, editors)	720
Unknown	23
Readers By Professional Status	Count
Student > PhD Student	200464
Researcher	160291
Student > Master	132881
Student > Bachelor	116727
Student > Doctoral Student	30947
Student > Postgraduate	17433

Tweeters By Type of Membership	Count
Professor > Associate Professor	6963
Professor	397
Unspecified	9
Others	282680
Readers By Discipline	Count
Medicine and Dentistry	257874
Agricultural and Biological Sciences	251495
Biochemistry, Genetics and Molecular Biology	140170
Chemistry	27943
Engineering	17674
Pharmacology, Toxicology and Pharmaceutical Science	13444
Immunology and Microbiology	8241
Computer Science	7441
Nursing and Health Professions	5932
Physics and Astronomy	2669
Materials Science	1479
Psychology	1325
Social Sciences	1086
Environmental Science	623
Neuroscience	376
Mathematics	372
Sports and Recreations	314
Earth and Planetary Sciences	96
Veterinary Science and Veterinary Medicine	38
Business, Management and Accounting	21
Arts and Humanities	18
Economics, Econometrics and Finance	16
Chemical Engineering	1
Unspecified	63
Others	211149

Table 4 presents the top ten articles with the highest AAS. According to this table, the most highly cited article in this field on social media was "Dermatologist-level classification of skin cancer with deep neural networks" by Esteva et al. (2017), published in Nature in 2017, with an AAS of 2864. The article by Begley C.G. and Ellis L.M. titled "Drug development: raise standards for preclinical cancer research," published in Nature in 2012 with an AAS of 2018, ranked second, and the article by Siegel R.L et al. titled "Cancer statistics, 2017", published in the CA Cancer Journal for Clinicians in 2017 with an AAS of 1704, ranked third on the list.

Table 4

Top ten highly mentioned of highly cited publications in the field of cancer

PT	FA; Y	CB	AAS	J	DT
Dermatologist-level classification of skin cancer with deep neural networks	Esteva A; 2017	2072	2864	Nature	Article
Drug development: raise	Begley C.G; 2012	1396	2018	Nature	Article

PT	FA; Y	CB	AAS	J	DT
standards for preclinical cancer research					
Cancer statistics, 2017	Siegel R.L; 2017	7602	1704	CA Cancer Journal for Clinicians	Article
Cancer statistics, 2018	Siegel R.L; 2018	2838	1625	CA Cancer Journal for Clinicians	Article
Reduced lung cancer mortality with low-dose computed tomographic screening	Aberle D.R; 2011	4396	1612	New England Journal of Medicine	Article
Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries	Bray F; 2018	8223	1480	CA Cancer Journal for Clinicians	Article
Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 32 cancer groups, 1990 to 2015: a systematic analysis for the global burden of disease study	Fitzmaurice C; 2017	1378	1450	JAMA Oncology	Review
Cancer statistics, 2016	Siegel R.L; 2016	16965	1424	CA Cancer Journal for Clinicians	Article
Cancer statistics in China, 2015	Chen W; 2016	7848	1386	CA Cancer Journal for Clinicians	Article
Cancer statistics, 2019	Siegel R.L; 2019	2639	1334	CA Cancer Journal for Clinicians	Article
PT: Publication Title; FA; Y: First Author; Year; CB: Cited By; AAS: Altmetric Attention Score; J: Journals; DT: Document Type					

Table 5 presents the characteristics of the ten publications with the highest AAS, including their presence on various social media platforms. The top-ranked article in the field of cancer, "Dermatologist-level classification of skin cancer with deep neural networks," has the highest AAS and has been shared widely: 142 times by news outlets, 43 times by blogs, 3 times through policy sources, 2039 times through Twitter, 7 times through patents, 42 times through Facebook pages. The article has also received 1 citation on Wikipedia and has 3768 readers on Mendeley and 9 readers on CiteULike. Also, it has 22 readers on Google+ users.

Table 5
Top ten publications with the highest AASs in different social media

Title	News Outlets	Blogs	Policy Sources	Tweeters	Patents	Facebook	Wikipedia	Mendeley	CiteULike	Google + Users
Dermatologist-level classification of skin cancer with deep neural networks	142	43	3	2039	7	42	1	3768	9	22
Drug development: raise standards for preclinical cancer research	85	117	5	1006	2	38	2	1549	30	21
Cancer statistics, 2017	144	12	0	770	0	19	2	4446	1	5
Cancer statistics, 2018	139	10	0	747	1	9	0	4411	0	6
Reduced lung cancer mortality with low-dose computed tomographic screening	45	33	2	298	6	24	1	1746	4	1
Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries	114	9	3	1046	0	4	7	13016	0	2
Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 32 cancer groups, 1990 to 2015: a systematic analysis for the global burden of disease study	137	4	1	572	0	26	0	1300	0	12
Cancer statistics, 2016	152	6	0	269	1	17	1	3396	1	1
Cancer statistics in China, 2015	169	4	0	55	1	3	0	1264	1	2
Cancer statistics, 2019	94	9	0	778	0	5	1	5535	0	1

Spearman's correlation test was used to test the research hypothesis that there is a positive and significant correlation between received publication citations and altmetric indicators across different social networks due to the non-normality of the variables being analyzed.

As shown in Table 6, the correlation coefficient (r) between the two variables of the examined cancer articles is 0.283, which is statistically significant (p-value < 0.001). Therefore, it can be concluded that there is a positive moderate relationship between the received citations of the reviewed publications and their AAS.

Table 6
Results of Spearman's correlation analysis between received citations and AAS

Variable	Publications AAS	
	r	p-value
Publications Citation	0.283	< 0.001

The correlation analysis presented in Table 7 indicates a positive and statistically significant relationship between the received citations of the reviewed articles and their altmetric indicators in all the social media platforms examined, except for LinkedIn (p-value = 0.923). Therefore, we can confirm the presence of a positive and significant relationship between the received citations of the reviewed articles and their altmetric indicators. It should be noted that apart from the moderate relationship between the number of citations with Readers on Mendeley and Patents, there is a weak relationship between the other variables. In general, the findings suggest that the visibility of publications on social networks may enhance their likelihood of receiving citations

Table 7

Results of Spearman's correlation analysis between received citations and altmetric indicators

Variables	Publication Citations	
	r	p-value
Readers on Mendeley	0.411	< 0.001
Tweeters	0.178	< 0.001
Facebook Pages	0.151	< 0.001
Google+ Users	0.137	< 0.001
Readers on CiteULike	0.239	< 0.001
Blogs	0.238	< 0.001
Wikipedia Pages	0.228	< 0.001
News Outlets	0.164	< 0.001
Reddit	0.105	< 0.001
Patents	0.31	< 0.001
Readers on Connotea	0.173	< 0.001
LinkedIn User	0.003	0.923

As shown in Table 8, the correlation between journal IF and AAS and between journal CiteScore and AAS for the examined cancer articles are 0.217 and 0.133, respectively, both of which are statistically significant (p-value < 0.001). Therefore, based on the correlation coefficients, it can be concluded that there is a positive weak relationship between journal IF and CiteScore with AAS.

Table 8

Results of Spearman's correlation analysis between journal Impact Factor and CiteScore with AAS

Variables	Publications AAS	
	r	p-value
Journal IF	0.217	< 0.001
Journal CiteScore	0.133	< 0.001

Discussion

Cancer is a major health problem worldwide. Research in this field has seen a significant increase in the number of publications over the past decades, indicating its importance in the field of medicine. Online social media has become an increasingly important platform for patients, clinicians, funding agencies, institutions, and journals to share and discuss research

outputs. As a result, a metric that measures the online impact of an article is becoming more relevant and important (Hassona et al., 2019). This study is the first to comprehensively assess the online attention received by published cancer articles with such a detailed approach. It explores popular publications and reveals aspects in which the scientific community and society in different domains could benefit from increased interaction in social contexts. So, in this study, the presence of highly cited publications related to cancer on social media was investigated using altmetric indicators.

In our study, the median of AAS was 22 (range from 1 to 2864); this value in a cohort study examining the factors that influence the attention given to cancer treatment research in online media was equal to 2 (range from 0 to 428) (Haneef, Ravaud, Baron, Ghosn & Boutron, 2017). Our results showed that out of 1000 publications, 963 articles (96.3%) were mentioned at least once on social media websites and tools, according to the Altmetric Institute. This high percentage suggests that researchers in the field of cancer utilize social media facilities and capabilities extensively. However, this result is not consistent with the findings of Costas, Zahedi & Wouters (2015), who reported that only 15% to 24% of publications were present on social media due to limited coverage of altmetric service providers. The research by Robinson-García, Torres-Salinas, Zahedi & Costas (2014), also produced different results, indicating that only 19% of all publications indexed in the Web of Science (WoS) database were mentioned in social media.

Examining different types of social media showed that Mendeley was the main altmetric source for highly cited publications, with 99.6% of publications in Mendeley having been read. In other words, out of the 1000 highly cited publications in the subject area of cancer, 996 publications had at least one reader in Mendeley. In some previous studies, the Mendeley referencing tool and Twitter have been mentioned as the most important social media used by researchers (Costas, Zahedi, & Wouters, 2015; Hammarfelt, 2014; Kolahi, Iranmanesh & Khazaei, 2017; Robinson-García et al., 2014). Researchers have introduced Mendeley as one of the most important tools for presenting publication-level data and altmetrics (Zahedi, Costas & Wouters, 2014). Mendeley's importance in disseminating scientific output is highlighted by the presence of highly cited cancer articles in its database, as noted by Costas, Zahedi and Wouters (2015), Hammarfelt (2014), Haustein, Costas and Larivière (2015), Kolahi and Khazaei (2016), Ravenscroft, Liakata, Clare and Duma (2017) and Robinson-García et al. (2014). This is because this tool, in comparison with other social media, provides users with information such as the name of the country, their field of study, and their job position, and it creates cooperation and sharing of research with other users (Fenner, 2014; Haustein, Larivière, Thelwall, Amyot & Peters, 2014).

In total, the highly cited publications were tweeted and read in Mendeley by readers from more than 90 countries around the world. The USA had the highest number of tweeters and readers. According to Fenner (2014), widespread tweeting of an article on Twitter indicates the attention of the scientific community towards that document or its creator's reputation, but it does not necessarily mean the document is effective. Reviewing the tweeted articles revealed that the information about the publication of the article was mostly provided by members of the public. This demonstrates the potential of web-based tools in disseminating scientific information to the public. This finding is inconsistent with the studies of Hammarfelt (2014) and Mazov and Gureev (2015), as their research showed that publishers mostly tweet scientific articles for advertising purposes. Therefore, it can be concluded that in highly cited articles,

information on Twitter is mostly shared by members of the public. In terms of professional status, most readers were PhD students, which is consistent with the research of Pooladian and Borrego (2017). Additionally, most readers were from the fields of medicine and dentistry.

Considering the widespread use of social media by people and the concentration of altmetrics data on publications published since 2011, this study examined the number of publications with the highest citations, which showed the prevalence of social media use in recent years. This result is consistent with the findings of the study by Costas, Zahedi and Wouters (2015). According to the findings of the current study, the highest AAS belonged to the article titled "Dermatologist-level classification of skin cancer with deep neural networks" (Esteva et al., 2017), which received a score of 2864. This English original article was published in *Nature* and highlights the use of deep convolutional neural networks (CNNs) for the automated classification of skin lesions, addressing the challenges posed by the visual diagnosis of skin cancer. Trained on a vast dataset of 129450 clinical images encompassing 2032 diseases, the CNN demonstrates comparable performance to board-certified dermatologists in identifying keratinocyte carcinomas, benign seborrheic keratoses, malignant melanomas, and benign nevi. The study suggests the potential for mobile devices equipped with artificial intelligence (AI) to aid dermatologists in diagnosing skin cancer, expanding access to vital diagnostic care beyond the clinic setting. Examining the frequency of the top 20 publications with the highest AAS showed that 80% of these documents were original articles and 20% were review articles, which is consistent with Goksoy and Bozkurt's (2020) study, in terms of the majority type of articles with the highest AAS.

The highest-scoring article in the field of cancer titled "Dermatologist-level classification of skin cancer with deep neural networks" has the highest AAS, with 142 news outlets, 43 blog posts, 3 policy sources, and 2039 tweets sharing it. It has also been shared 7 times through patents, 42 times through Facebook pages, 22 times through Google+ users, 2 times through Redditors, 1 time through a research highlight platform, 1 time through Q&A threads, and 5 times through video uploaders. The article has received 1 citation in Wikipedia, 3768 readers in Mendeley, and 9 readers in CiteULike. The correlation between citations and altmetric indicators in highly cited publications demonstrates a significant and positive statistical relationship between publication citations and the number of tweets, blog posts, Facebook shares, Google+ users, Redditors, patents, news stories, citations in Wikipedia, and Mendeley, CiteULike, and Connotea readers. The correlation was moderate only in the case of Mendeley and patents and weak in other instances. Also, a significant statistically moderate correlation between AAS and the number of citations ($p < 0.001$) has been reported in previous studies (Ali, Dobbs, Slade & Whitaker, 2021; Goksoy & Bozkurt, 2020; Powell, Bevan, Brown & Lewis, 2018), indicating that social media has a positive effect in increasing the number of citations to publications. This correlation was also reported weakly in some other studies (Nocera, Boyd, Boudreau, Hakim & Rais-Bahrami, 2019; Rong, Lopes, Hameed, Gaudino & Charlson, 2020).

The results of Bayar and Peksöz (2022) on breast cancer contradict our findings. The sample size of this study is much smaller (50) compared to our study (1000), and it only focused on a single type of cancer. One influential factor could be that the authors and researchers in this domain might not have had sufficient familiarity and awareness about altmetrics given the limited number of articles. The absence of a significant relationship does not imply that altmetric indicators are ineffective or of little impact. However, this lack of correlation suggests

that altmetric analysis evaluates different aspects of articles compared to traditional citation analysis. In general, as the number of articles examined increases, the generalizability of the results also improves. As the study itself acknowledged in its limitations section, selecting a higher number of articles could have enhanced the study's power. According to the findings from Goksoy & Bozkurt (2020), the absence of a strong relationship between the AAS and the number of citations indicates that having a high citation count for scientific articles may not necessarily lead to an equivalent level of attention on social media platforms, which is a plausible and not unexpected result. Finally, the results of the statistical test regarding the correlation between AAS and journals IF/CiteScore were also reported to be significant ($p < 0.001$). Most studies on conventional criteria state that highly cited articles are often published in high IF journals (Feijoo, Limeres, Fernández-Varela, Ramos & Diz, 2014; Kolkailah et al., 2019; Shuaib & Costa, 2015). This result is contrary to (Dardas, Woodward, Scott, Xu & Sawair, 2019; Delli, Livas, Spijkervet & Vissink, 2017) studies, that the subject area and the number of reviewed journals are not insignificant in this discrepancy. It seems that the perceived generalizability of research and its potential real-world applications carry more weight than the scientific importance or the level of scientific evidence presented by the study itself. This insight, when combined with the assessment of the accuracy and consistency of altmetrics data and tools, can offer a deeper understanding of the implications of altmetrics and unveil hidden dimensions for future studies.

Conclusion

In general, researchers want their articles to be seen and cited more by publishing them in influential journals (Ahmadian et al., 2021). AAS analysis is a novel measure of citations in social media. The research findings indicate that social media-based indicators can have a positive impact on the number of citations received by publications (Peres, Braschinsky, & May 2022; Thelwall, Haustein, Larivière & Sugimoto, 2013). As complementary measures to citation-based indicators, they can be used to evaluate scientific outputs and researchers' performance and provide insight for journal editors and editorial board members on the benefits of using social media platforms to publish articles. Therefore, it is recommended that journals, writers, and researchers utilize social media to increase the visibility of their articles and garner more citations. Using social media can certainly promote medical scholars' scientific interactions and add value to research and innovation. Given the importance of utilizing social networks for scientific purposes, policymakers and officials must reconsider their approach to filtering scientific activities on these platforms. Additionally, research institutions should consider scientific social networking as a criterion for promotion, to increase the visibility and impact of scientific work. It is necessary to educate all members of society, particularly researchers, about scientific social networks, how to actively participate, and the benefits of using them. In summary, to create a comprehensive approach to evaluations, the combination of altmetrics with traditional citation metrics will have more effective results. Both perspectives offer important, different, and complementary views that should not be ignored.

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Conflict of Interests

The authors declare that they have no conflict of interest.

Ethical Consideration

This study has been ethically approved by the Ethics Committee of Hamadan University of Medical Sciences with code number: IR.UMSHA.REC.1398.632.

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