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Evaluation of the Altmetrics Impact of Retracted Articles: The Case of Five Prominent Articles

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Abstract
Altmetrics are new bibliometric methods with increasing popularity, meant to reveal the impact and public attention for scientific research. In addition to the traditional bibliometric scores (such as article citation counts, h-index, or journal impact factor), any research paper published online can have algorithm-generated Altmetric scores linked to a digital identifier (for example, DOI-Digital Object Identifier). In this article, we have analyzed five papers withdrawn from publication: 4 papers with the highest citation scores until December 2020 according to the ***Retractionwatch.com*** database and one COVID-19-related paper with the highest Altmetric score. By contrasting traditional bibliometrics according to the Web of Science database (like article citation counts before and after retraction) with Altmetric details (like Attention score, Mendeley mentions, Twitter mentions, News outlets) we have shown that the highest citation scores for bibliometrics were not reflected in Altmetric scores and vice-a-versa. We observed that all the cases of retracted papers with the highest citation counts came from the top 25% most appreciated scientific journals. Moreover, these articles attracted citations even long after retraction from publication, and if these articles were to be selected for the creation and application of secondary scientific literature, we fear it could lead to inaccurate results. The Attention score, also known as the Altmetric score, is meant to complement traditional bibliometrics and produce a more complex evaluation for scientific work (a scientific assessment and a social interest/ impact assessment).

Keywords: Altmetric; Bibliometric; Retracted article; New score

Introduction

Professionals from various fields around the world have always shown an ongoing interest in the impact of their scientific discoveries. This interest is not limited to the researchers' fields of expertise, but the impact has extended to a broader context, from the impact on the scientific community and beyond, including the impact at the social level [1].

The entire scientific publishing world has undergone a significant change with the advent of the Internet and its development. Specialized literature has undergone changes that have been compared to the printing press revolution. The Internet plays an essential role in literature as we know it now. The Internet creates connections between extremely diverse fields, reduces geographical barriers, and

facilitates communication between researchers and the working groups to which they are affiliated, all of which were difficult to achieve or even impossible in the era of printed scientific articles. Equally, the digitization of specialized literature has created a favorable environment for developing new ways to evaluate scientific publications' impact and follow an article's journey [2].

In 1969, Alan Pritchard coined the term bibliometry as the application of mathematical and statistical methods in the study of books and other media [3]. In the beginning, scientists aimed to study scientific papers and their bibliographies primarily for good library management. The activities undertaken for good management of the libraries were the cornerstone of creating the laws underpinning bibliometrics. In the early 1960s, the Science Citation Index (SCI) was created, which led to a closer analysis of the relationship between citations and the characteristics of scientific work, the collaboration between authors, the number of references, and the scope of research. In the academic world, there are ongoing debates about the application and validity of these parameters for research evaluation. The studies evaluating these parameters led to a closer understanding of these indicators, ultimately leading to the improvement or creation of adequate bibliometric indicators [4].

Bibliometric indicators (BI) are data that reflect either the consumption or the production of a scientific article. They are the final product of calculations that use a large volume of data related to scientific work. The information used in BI calculations is available in international reference databases. Bibliometric indicators are of several types and may relate to journals (e.g., Impact Factor (IF), Scimago Journal Rank) or to researchers (e.g., the H-index or the collaboration index) [5].

Since the purpose of BIs was not to measure public interest in research, alternative metrics were needed. Any scientific work, including book chapters, journal articles, and clinical studies, has the potential to receive a public attention score. This score accounts for the online impact that the scientific paper has, and the required condition is the existence of a digital identifier (DI) like: Digital Object Identifier (DOI) or PubMed Identifier (PMID) used for scientific articles or International Standard Book Number (ISBN) used for books [5]. Regarding Altmetric calculations, only the links that contain the DI of the paper are included. A mere picture of an article containing the title and the authors' names is not considered for the Altmetric score or Attention score [6].

What is Altmetric? How do Altmetrics Work?

Altmetrics is a term that was first used in 2010 by Jason Priem in a Twitter message (also known as a tweet). Altmetrics refers to a new concept in bibliometrics [1]. Priem and his peers defined this new concept as being a suite of new methods for measuring the impact of an article, which are based on Social Web analysis. Altmetrics is not considered an alternative to traditional metric methods (based on citation counts), but a complementary method aimed to create a more complex overview from the point of view of the impact that an article has [2]. Any scientific paper that has a Digital Object Identifier or any other standard identifier can have a score generated by Altmetric.com based on the data it collects from various online sources [7], as follows:

a) **Social networks**, here we mention both the main ones (*Twitter*, *Facebook*, *Youtube*, etc.), as well as the social scientific networks (*ResearchGate*, *LinkedIn*, *Academia.edu*) [8];
b) **Online reference management tools**, we mention the most widely used, such as *Mendeley* and *Zotero*. Altmetric records the number of users who, using these online tools, saved any article in the virtual environment [9];
c) **Blogs** are used by Altmetric to calculate its scores. It considers both general blogs and blogs dedicated to the scientific community. If we are talking about a blog with scientific content, publications need to be validated by the academic community. Anyone can post on general blogs. One of the most visible academic blogs is *Research blogging*;
d) **Open Access repository**, are free sources of information, such as databases that are available online, permanently: like *DOAJ (Directory of Open Access Journals)* and *Figshare*;
e) Altmetric also refers to **other media sources** such as the *New York Times*, *The Guardian*, or documents published by governments.

The Altmetric score is centered on the multicolored "Donut" (the Altmetrics logo), representing the sources on which the score was based on. For instance, blue corresponds to Facebook, turquoise corresponds to the Twitter platform, red represents the main media sources, and yellow to blogs [10].

In terms of costs, the services provided by Altmetric are based on subscriptions. Subscriptions relate to various institutions and publishers around the world. A Bookmarklet is a browser tool intended for researchers and the public, being available free of charge for instant viewing of an Altmetric score or Attention score for certain scientific articles, like those indexed in PubMed, those with a DOI. Altmetric Bookmarklet also has some limitations, like just the tweets for articles published since July 2011 [1].

The Purpose of this Paper

In this paper, we examined five articles retracted from publication according to the ***Retractionwatch.com*** database. We selected the top four articles with the highest Web of Science citation rates (considered traditional bibliometric), and then examined the Altmetric score to determine if there were similarities. For the fifth article, we selected the COVID-19 article with the highest Altmetric score, and we then investigated whether the Web of Science citation rates reflected the social impact the article had.

Material and Method

The ***Retractionwatch.com*** database provided us with a ranking of the most cited scientific articles withdrawn from publication until December 2020 [11]. Since they were the most cited on Web of Science, we considered them as most prominent from the list. This ranking provided for each of the articles classic bibliometric data, like the total number of citations from Web of Science (WoS) indexed journals, the number of citations before and after retraction. These article citations were the ones registered up until December 2020 and were based on the "Citation index" section of the WoS from Clarivate Analytics, which only counts citations from journals included in the WoS Core Collection.

In addition to this data, we searched on the **WoS website** and based on "Citation index" we extracted for each article the following data: total citations from August 2022, citations after retraction from August 2022 *(=retraction citations from Dec 2020 + (Aug 2022 total citations – Dec 2020 total citations)*), journal Impact Factor (IF) based on the article's year of publication and journal ranking (quartile from 1-4).

The search from August 2022 on the **Altmetrics website** provided for each retracted article the following parameters measuring the societal impact and public interest: Attention Score and counts for News outlets, Policy sources, Blogs, Twitter mentions, Facebook pages, Wikipedia pages, Video uploaders, Google+ users, Mendeley mentions, CiteULike.

We presented below the bibliometric and Altmetric characteristics of the first four most cited retracted articles up until December 2020 [12-15], but decided to switch the criteria for the 5th article.

For the last couple of years, humanity has faced COVID-19, a new disease that has ultimately been declared a pandemic. Scientists focused on SARSCOV-2 coronavirus and COVID-19 research topics. The academic community was very interested in research results for this topic, and so was the public. Consequently, in August 2022 we searched papers referring to COVID-19 or SARSCOV-2 on ***Retractionwatch***, and found a collection of 253 retracted articles and 13 articles with "Expression of concern". Analyzing this list of retracted articles from the Altmetric score point of view, we identified the one that reached the largest audience [16].

Results

Article #1

The most cited retracted article was "Primary Prevention of Cardiovascular Disease with a Mediterranean Diet" by Estruch et al., an article published in The New England Journal of Medicine in April 2013 and retracted in 2018. According to WoS, 682 out of 2850 citations came from review and meta-analysis articles (Table 1).

Table 1. Article #1-WoS bibliometric data

Time from publication to retraction	**~5 years (2013-2018)**	
Citations before retraction (2018)	1919	
Citations after retraction (WoS)	Dec 2020	816
	Aug 2022	931
Total Citations (WoS)	Dec 2020	2735
	Aug 2022	2850
IF (publication year)– Journal Quartile	54.420 – Q1	

The article's Attention score was 4130 and the Altmetric details are presented in Figure 1.

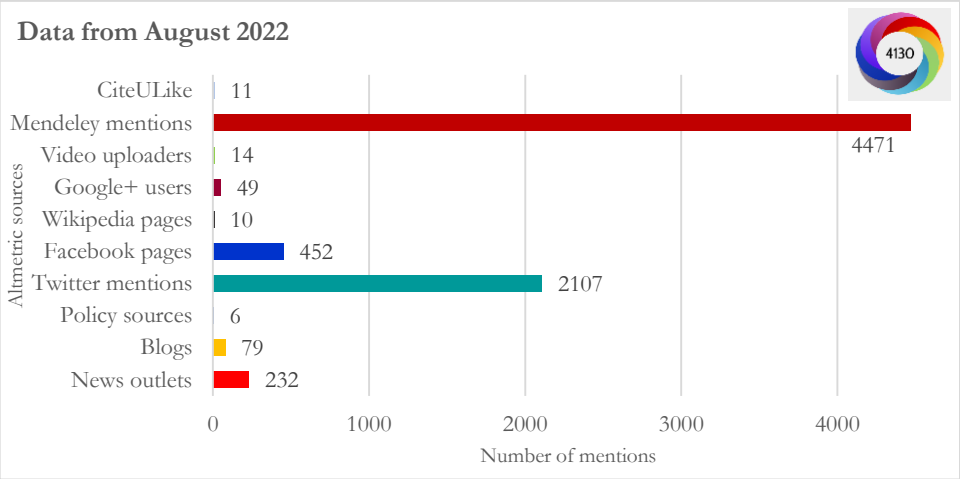

Figure 1. Attention score and Altmetric sources and number of mentions for Article #1

Article #2

The second most cited retracted article, entitled "Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children." by Wakefield et al., was published in The LANCET in February 1998 and was retracted in 2010. This article found a link between vaccines administered in childhood and parity of an autoimmune digestive pathology. According to WoS, 235 out of 1561 citations came from review and meta-analysis articles (Table 2).

The article's Attention score was 4309 and the Altmetric details were presented in Figure 2.

Table 2. Article #2 - WoS bibliometric data

Time from publication to retraction	~12 years (1998-2010)	
Citations before retraction (2010)	642	
Citations after retraction (WoS)	Dec 2020	867
	Aug 2022	919
Total Citations (WoS)	Dec 2020	1509
	Aug 2022	1561
IF (publication year)– Journal Quartile	11.793 – Q1	

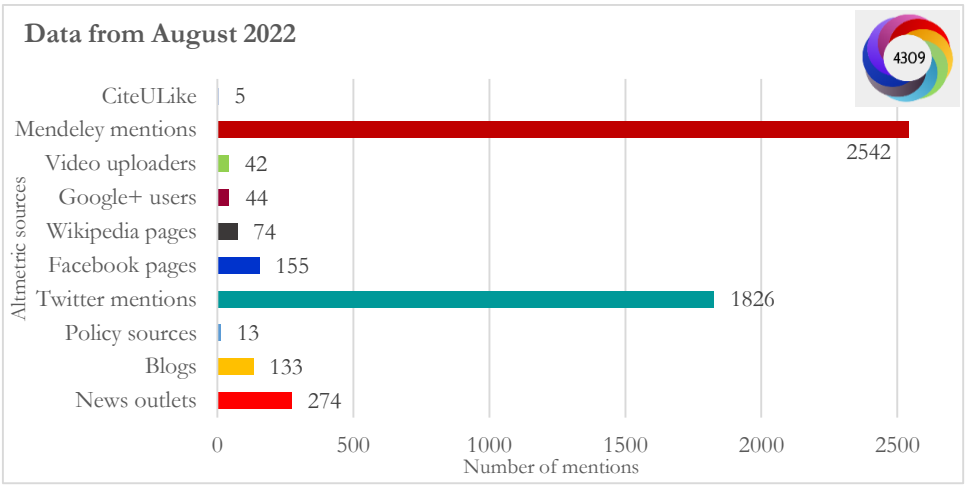

Figure 2. Attention score and Altmetric sources and number of mentions for Article #2

Article #3

The third most cited retracted article was entitled "Visfatin: A protein secreted by visceral fat that mimics the effects of insulin" published in Science by Fukuhara et al., in January 2005, and retracted in 2007. According to WoS, 371 out of 1451 citations came from review and meta-analysis articles (Table 3).

Table 3. Article #3-WoS bibliometric data

Time from publication to retraction	~2 years (2005-2007)	
Citations before retraction (2007)	232	
Citations after retraction (WoS)	Dec 2020	1192
	Aug 2022	1219
Total Citations (WoS)	Dec 2020	1424
	Aug 2022	1451
IF (publication year)– Journal Quartile	30.927 – Q1	

The Attention score that this article received was only 31, as detailed in Figure 3.

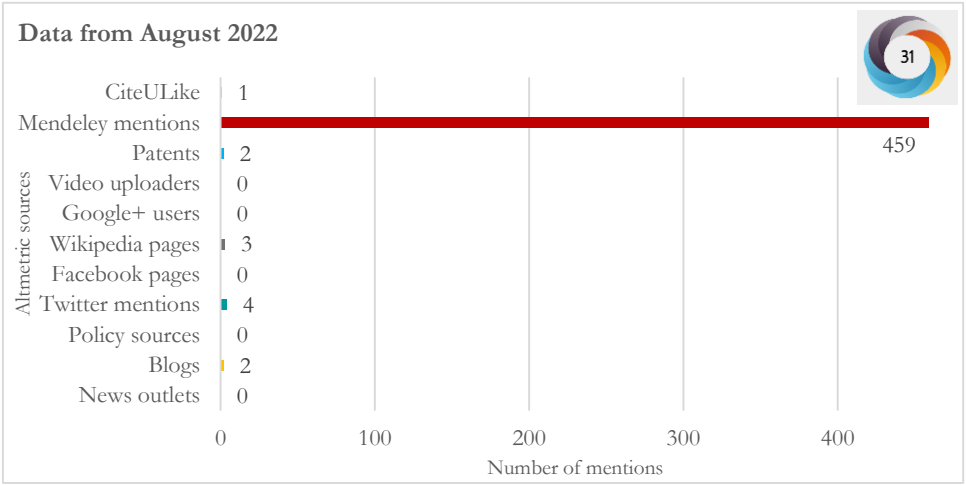

Figure 3. Attention score and Altmetric sources and number of mentions for Article #3

Article #4

The fourth most cited retracted article, "An enhanced transient expression system in plants based on suppression of gene silencing by the p19 protein of tomato bushy stunt virus." was published by Voinnet et al. in the Plant Journal in March 2003 and got retracted in 2015. According to WoS, 54 out of 1307 citations came from review and meta-analysis articles (Table 4).

Table 4. Article #4-WoS bibliometric data

Time from publication to retraction	~ 12 years (2003-2015)	
Citations before retraction (2015)	896	
Citations after retraction (WoS)	Dec 2020	375
	Aug 2022	411
Total Citations (WoS)	**Dec 2020**	**1271**
	Aug 2022	1307
IF (publication year)– Journal Quartile	5.914 – Q1	

The Attention score registered by this article was 63, Altmetrics detailed in Figure 4.

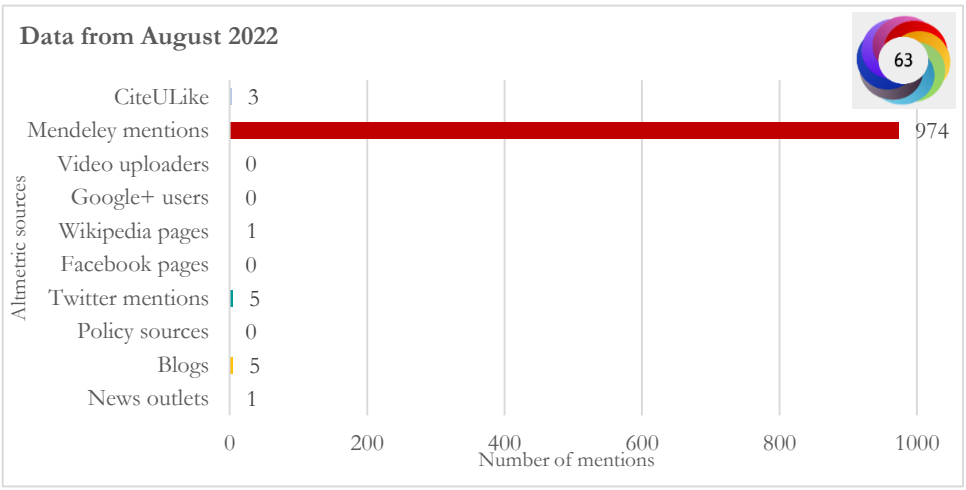

Figure 4. Attention score and Altmetric sources and number of mentions for Article #4

Article #5

The COVID-19 related article, retracted from publication and having the highest Attention score was "*Hydroxychloroquine or chloroquine with or without a macrolide for treatment of COVID-19: a multinational registry analysis*" by Mehra et al. The article was published in May 2020 in The Lancet and was withdrawn from publication after 26 days (in June 2020). According to WoS, 226 out of 737 citations came from review and meta-analysis articles (Table 5).

Table 5. Article #5-WoS bibliometric data

Time from publication to retraction	~14 days (May 2020 - June 2020)	
Citations before retraction	53	
Citations after retraction (WoS)	Dec 2020	346
	Aug 2022	684
Total Citations (WoS)	**Dec 2020**	**399**
	Aug 2022	737
IF (publication year)– Journal Quartile	79.323 – Q1	

This article had a short publication span, but it received an Attention score of 22400 in Aug 2022, more explicitly described in Figure 5.

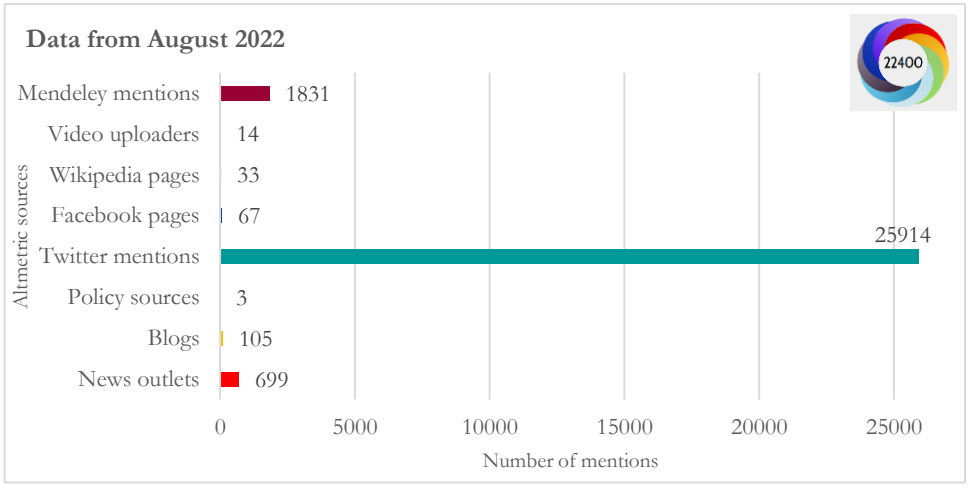

Figure 5. Attention score and Altmetric sources and number of mentions for Article #5

Discussion

Based on the number of citations (up until August 2022) from review and meta-analysis articles, we found it quite concerning that so many secondary literature publications cited retracted articles. Since the retractions were made for good reasons, using the retracted articles in secondary literature could lead to erroneous results. The worry is exacerbated because these review and meta-analysis articles might be used by clinicians and policymakers, which could negatively impact the patients. Another issue could be the one of research impact on both academia and the public, an obvious example would be Wakefield et al. retracted article on MMR vaccines that expedited the Anti-vaxers movement in parents fearful for their children's health and safety.[17]

Article #1

Article #1 was published in WoS high-ranking journal, with a high IF. Its publication duration of approximately five years gained almost 2000 citations and hundreds more after retraction. In other terms, it had a great impact, according to the bibliometric measures, but also a great interest of the public outside the strictly academic environment. This is supported by many mentions on Facebook or Twitter, as well as Mendeley mentions. We suppose that the high Altmetric or Attention score was due to the public's general interest in cardiovascular diseases. Cardiovascular diseases remain the leading cause of death worldwide. In 2016 alone, approximately 17.9 million deaths were reported, representing approximately 31% of total deaths globally [18]. Diet is a nonpharmacological, affordable and simple method available to anyone, therefore being the first step in many guidelines as it can positively impact the prevention of many diseases. Thus, the accessible language and the prevention method discussed in this article can explain the great interest in this article (Figure 1). The interest is validated by the highest number of traditional WoS citations (Table 1) according to the ***Retractionwatch.com*** database among the withdrawn articles, but also by the Altmetric score.

Article #2

Article#2 was published in a high-ranking journal in WoS, but its IF was smaller than Article#1 IF most likely because it was published much earlier and impact factors were not that high in that period. The Altmetric score for Article #2 was generated mostly from social networks, Wikipedia pages and numerous Mendeley mentions (Figure 2). Even though Article #2 had more than twice the publication duration as Article #1 (Table 2), the Altmetric score is about the same as for the

previous article (which was available for only five years). Years after Article #2's publication, social networks started to be deployed; for instance, Twitter launched in 2006 [19], which was also the year in which Facebook became available to the public. Thus, the Altmetric score depended on the duration of social networks' development and on the article's topic, which might be credited with piquing the public's curiosity. The topic of a link between autism and vaccination has proved to be a myth hard to vanquish from public opinion [20].

Article #3

The public is interested in Article#3's subject given that more than half of Europeans are overweight and up to 30% are obese and that obesity has been steadily rising internationally since 1980 as evidenced by the fact that this year's diagnoses of obesity have doubled [21]. This article was published in one of the most prestigious scientific journals in the world (very high IF) and received more than 1100 citations after retraction (Table 3). The increased number of Mendeley mentions also demonstrated the research community's interest (Figure 3). A low Altmetric score may be due to two factors: first, the article was only online for two years, and second, people who work in sectors other than medicine are not generally aware of the subject.

Article #4

Similar to Article #2, Article#4 was published before the social networks were firmly in motion and had a long publication period. The citation counts were large enough to suggest a high interest in the academic community (Table 4). In contrast to the lengthy availability of this article—more than ten years between publication and withdrawal—the Altmetric score is modest, relying mostly on Mendeley mentions (Figure 4). We could argue that one of the causes was the specialized language which was not accessible to all people outside that scientific field.

Article #5

This article was published in one of the most prestigious scientific journals in the world (very high IF). It did not receive many citations, but this could be because it was retracted promptly after publication (Table 5). The article was withdrawn from publication, and the data it promoted were invalidated. Nevertheless, the article was published at a time when the whole of humanity was threatened by a new disease for which there were no specific treatment or prevention methods. Therefore, the social context and the subject that the article addressed, namely a possible treatment for this new disease (COVID-19), attracted the attention of the public.[22] Its Attention score was extremely high (22400 – Figure 5) compared to the attention scores of the above-mentioned articles. Therefore, the subject and social context can influence the Altmetric score, but it cannot guarantee the quality of the promoted information, nor can it validate this information.

General Overview

All five retracted articles were published in Q1 ranked journals, very respected and highly appreciated journals in their field, all having high IFs. The journal's ranking could explain the researchers' ease of expecting high-quality articles, but this does not excuse them from not checking whether the chosen articles for secondary literature were retracted.

Whether the time from publication to retraction of an article was 12 years, 5 years, 2 years, or even 14 days, researchers still cited retracted articles for review and meta-analysis articles.

The trend in research topics can be easily observed based on Attention scores (or Altmetric scores):

- Altmetric scores had the tendency to increase when, besides researchers' interest showcased by Mendeley mentions, the social media mentions and news outlets were high as well (Article #1, #2 and #5).
- When the research topic was of little interest to the public, social media mentions were scarce. Thus, Altmetric scores were low too. Mendeley mentions (attributed to researchers' interest) were the only parameter elevating the Altmetric scores in Article #3 and #4.

- A very high Altmetric score was not a reflection of how important the academic community viewed an article or a topic (Article #5).

The Internet is constantly evolving year by year. Nowadays, researchers have all the tools necessary to make their research known on any platform and to attract the attention of the wider public, not only in the fields in which they practice [23]. The impact of the development of social networks in recent years has influenced the Altmetric score. The further the year of publication of the article is from the current one, the less developed the social networks were, and the lower the Altmetric score could be.

Traditional bibliometric indicators have been shown to be good indicators of the quality of the content of a scientific paper. The number of citations recorded by an article accumulates slowly over several years [24]. Therefore, the impact based on citations cannot be assessed during a time interval of less than 2 or 3 years [25]. Therefore, time can validate the quality of a paper, but Altmetric remains just an indicator of its successful spread in the online world.

Some articles that aimed to investigate the relationship between traditional bibliometric scores and the Altmetric score have succeeded in proving the existence of a positive correlation, even if weak, in terms of articles in the literature related to the specialty of orthopedics [26]. Also, in the field of orthopedics, Zhang has shown a positive relationship between the number of citations in specialized journals and the Altmetric score in terms of recent academic research in orthopedics [27]. The dissemination of this information on social media seems to have brought a larger number of citations and implicitly a larger number of readers. Equally, the dissemination of scientific information through social networks is due to the increase in the number of researchers who use social networks. The number of researchers and physicians who use social networks to disseminate scientific information exceeds 90% today [26, 28]. Moreover, not only members of the academic community have resorted to social networks to further disseminate the results of research, but the scientific journals themselves have begun to create accounts on social networks to help disseminate information and increase the visibility of scientific articles [27].

Most studies confirm that Altmetric cannot be used as a parameter that accurately indicates the quality and value of research [29]. In generating the score, Altmetric presents an algorithm that has several sources from which it collects information, and their share in generating the final score is intensely debated. One of the "confusing" factors that seem to strongly influence the final Altmetric score is giving each tweet equal importance in forming the final score. On the other hand, impressions on the Facebook platform, such as "like" or "comment" are quantified as "posts". The authors evaluating these scores argue that the initial tweet or post should be considered more important than a "like" or "comment" when generating the Altmetric score. Bearing this in mind, it is suggested to consider the Altmetric score as a supplement and not a substitute for traditional bibliometric measures [30,31].

Summing-Up

The Altmetric score is obtained by an article following the collection of data related to it from various online sources and offers an overview of the societal interest in the topic (or online popularity). Altmetric is a new concept in full expansion, which cannot fully replace traditional bibliometric metrics, but complement them for an overview. The Altmetric score can be influenced by the period, time the article was published, social context, and topic. The Altmetric scores must still be viewed and interpreted with caution.

The Altmetric score can be affected by many variables that it considerably deviates from more traditional bibliometric metrics like citation counts and Impact Factor. Therefore, we cannot interpret the quality of an article by just considering the Altmetric score.

The present article has some limitations. One of the limitations is represented by the fact that we investigated data made available by only one database, namely *Retractwatch.com*. Among the articles whose impact we investigated were only the first four from the list of retracted according to Retractionwatch.com and only one that refers to the new disease, COVID-19. Another important aspect is represented by the fact that journals with free access or with paid access were not considered,

or if the impact factor of the journal can influence the analyzed scores. For future research, we recommend a larger data collection that enables statistical data analysis and comparison.

List of abbreviations

BI= Bibliometric Indicator
DI= Digital Identifier
DOI= Digital Object Identifier
DOAJ= Directory of Open Access Journals
COVID-19= Coronavirus disease 2019
IF = Impact Factor
Q1=1st quartile in journal ranking (from Clarivate Journal Citation Reports)
PMID=PubMed Identifier
SCI=Science Citation Index
WoS= Web of Science

Conflict of Interest

The authors declare no conflict of interest.

Authors' Contributions

Conceptualization, D.B.; validation, D.B. and A.E.U.C; resources, D.B and A.E.U.C; writing—original draft preparation, D.B and A.E.U.C.; writing—review and editing, D.B and A.E.U.C.; visualization, A.E.U.C; supervision, D.B.; project administration, D.B. All authors have read and agreed to the published version of the manuscript.

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