DOI: 10.14744/ejmi.2022.36412
EJMI 2022;6(1):128–139

Research Article

Evaluation of the Relationship between Cancer and Antioxidants from an Altmetric Perspective

Gokay Vardar,[1] Ferhat Hanikoglu,[2] Turkan Guney,[3] Mehmet Dokur,[4] Mehmet Karadag[5]

[1]Department of Medical Laboratory Techniques, Istanbul Health and Technology University, Vocational School of Health Services Faculty, Istanbul, Turkey
[2]Department of Medical Biochemistry, Alaaddin Keykubat University, Faculty of Medicine, Alanya, Antalya, Turkey
[3]Department of Medical Biochemistry, Beykent University, Faculty of Medicine, İstanbul, Turkey
[4]Department of Emergency Medicine, Biruni University, Faculty of Medicine, Istanbul, Turkey
[5]Department of Medical Biostatistics, University of Hatay Mustafa Kemal, Faculty of Medicine, Hatay, Turkey

Abstract

Objectives: Antioxidants have been shown in research to have significant effects on serious diseases, particularly cancer. The goal of our experiment was to determine and analyzed 100 articles with the highest Altmetric attention scores (AAS) concerning antioxidants and cancer.

Methods: Altmetric score analyzes were obtained downloading the from the Altmetric.com website. A research output's altmetric score was calculated using an algorithm based on the weighted number of all attention it receives.

Results: The Altmetric scores of the 100 articles analyzed varied from 12 to 846. Twitter (n=86) was the most mentioned social media network in the articles. According to the research categories of the T_{100} articles in our analysis, the majority were published in "Medical and Health Science". In terms of Twitter geographical breakdown, the United States leads among other nations, followed by the United Kingdom. According to Twitter demographics, the most of tweets on antioxidants and cancer were shared by members of the public.

Conclusion: In science and research, social media is advocated as an alternative to traditional power structures and our findings could provide a preliminary look at the social, clinical, and academic impact of antioxidant and cancer research.

Keywords: Antioxidants, altmetric analyze, cancer

Cite This Article: *Vardar G, Hanikoglu F, Guney T, Dokur M, Karadag M. Evaluation of the Relationship between Cancer and Antioxidants from an Altmetric Perspective. EJMI 2022;6(1):128–139.*

Reactive oxygen species (ROS), which are generated by various endogenous and exogenous stimuli, are dangerous to living cells owing to the presence of a highly reactive unpaired electron. Antioxidants supply the extra electron required to stabilize or degrade ROS; as such, the harmful effects of ROS are mitigated by the action of antioxidants. Consequently, the presence of antioxidants is essential to maintain a stable balance of ROS.[1,2]

Antioxidants can be classified as endogenous, dietary, and synthetic. Superoxide dismutase, catalase, and glutathione peroxidase are the most efficacious antioxidant enzymes.[3] Vitamin C, Vitamin E, carotenoids, thiol antioxidants (glutathione, thioredoxin, and lipoic acid), natural flavonoids, hormonal products of the pineal gland, melatonin, and other compounds are non-enzymatic antioxidants.[4] The compounds butylated hydroxyanisole (BHA), butylated

Address for correspondence: Gokay Vardar, pHD. Tıbbi Laboratuvar Teknikleri Programı, Istanbul Saglik ve Teknoloji Universitesi, Saglik Hizmetleri Meslek Yuksekokulu, Istanbul, Turkey
Phone: +90 551 723 34 90 **E-mail:** gokay.vardar@istun.edu.tr

Submitted Date: January 07, 2022 **Accepted Date:** February 15, 2022 **Available Online Date:** February 28, 2022

hydroxytoluene (BHT), propyl gallate, and tertiary butylhydroquinone (TBHQ) are synthetic antioxidants.[1,2]

Researchers have demonstrated that antioxidants can have major effects on serious diseases, especially cancers. High rates of ROS have been identified in all cancers, where they contribute to tumor development and progression. Therefore, antioxidants may prevent events in tumor development that are driven by ROS.[5]

Globally, cancer is a major cause of death.[6] Cancer is a disease that occurs as a result of the uncontrolled proliferation and growth of cells in any organ or tissue of the body. It is the second leading cause of death in the United States and a major public health problem worldwide. It is estimated that there were 1,735,350 new cancer cases in the USA in 2018; 609,640 resulted in patient death.[7]

The importance of a research article is often measured by the number of times it is cited by other authors; however, these citation rates do not always reflect the value of research. There are a few caveats regarding the use of citation-based metrics to assess the importance of research.[8] For researchers, the impact factor or *h*-index are famous traditional citation-based metrics. However, altmetric analysis is an emerging scientific tool. It serves as a complement to traditional citation-based bibliometrics, which measures the online attention surrounding scientific research outputs.[9,10,11]

Researchers and academics are frequently interested in the influence of their results, not just in their own fields, but also in the broader scientific community and even in mainstream media.[12] The influence of scientific papers on social media has not been assessed until recently. A new score (named Altmetric) was devised to assess this sort of impact. Each article's effect is measured by the amount of internet attention it receives. The Altmetric Attention Score represents how much attention an article receives in news outlets and blog comments, and the number of tweets and social media mentions.[13]

The aim of our study was to draw scientists' and researchers' attention to altmetrics as a resource for future research. To achieve this, we used data from altmetric.com and analyzed the 100 research articles on antioxidants and cancer with the highest Altmetric Attention Score, with reference to the following parameters: Dimension badges, mentioned by, Twitter geographical breakdowns, Twitter demographical breakdowns, and research categories.

Methods

Study Design

Altmetric score analysis

Level of evidence

Level III (according to SIGN50)

We acquired Altmetric Explorer (accessed May, 2021) utilizing the keyword "Antioxidant, cancer". The system provides more than 20 million original research articles. We obtained 1394 articles and analyzed the top 100 most cited articles (T_{100}) of these results. The Scottish Intercollegiate Guidelines Network (SIGN50, 2019) were utilized for source data on the level of evidence. The data were evaluated by examining the following parameters: titles, first authors, journal names, publication year, main subjects, dimensional badge, SIGN50 (level of evidence), mentioned by, twitter demographics, research categories, impact factor (IF), *h*-index, and Q category of journals. The top three most mentioned articles on social media, the top three areas with the most access to these articles by Twitter geographic breakdowns, the top three demographics with the most access to these articles by Twitter demographic breakdown, and the top three research categories of the articles were identified.

Altmetric Attention Score Analysis

The Altmetric Attention Score was obtained from the Altmetric.com website. An altmetric score is calculated utilizing an algorithm depending on the weighted number of all attention a research output gets. The score demonstrates the weighted number of the amount of concern for an altmetric score accepted for a research result. The failure weight and how the altmetric score is calculated is presented on the altmetric website. An altmetric score is dependent on three major units: sources, authors, and volume. Each color in the altmetric donut symbolizes a different source of relevance (Fig. 1). An altmetric score and altmetric donuts are created to make it easy to define how much and how interesting the various research results are.

Figure 1. Altmetric donut.

Statistical Analysis

The comparisons of altmetric and dimension badge values by month were made with the Kruskal–Wallis test and Dunn post hoc tests. As descriptive statistics, the mean±standard deviation for numerical variables, min–max, number, and percentage values for categorical variables are given. Spearman correlation coefficients were calculated to detect the linear relationship between numerical variables. Beta coefficients were estimated by univariate linear regression analysis. All analyses were performed using SPSS for Windows version 23.0. $p<0.05$ was considered as statistically significant.

Results

We found 1394 articles on "antioxidant-cancer" by searching Altmetric.com. The T_{100} articles were published between 2007 and 2021. Table 1 lists the articles with the top 100 altmetric scores (T_{100} list) in the antioxidant-cancer literature, along with the year of publication, first author, dimensional badge (total citations and recent citations), and altmetric attention score.

The total number of citations of the 100 articles ranged from 0 to 3800 (145.79±429.39) and recent number of citations of the 100 articles ranged from 0 to 718 (36.88±81.46). The altmetric score of the examined 100 articles ranged from 12 to 846 (59.64±110.20). Moreover, 20 of the examined 100 articles were published in 2011 and 2016 (Table 1).

Antioxidants (n=6), *Nutrition and Cancer* (n=5), and *Cancer Research* (n=3) were the journals in which the most T_{100} articles were published, respectively. 74% of T_{100} articles were published in Q1 journals, 16% in Q2, 6% in Q3 journals, and 2% Q4 journals. The impact factor (IF) range for journals in which the T_{100} articles were published varied between 74.699 and 0.27. The *H*-index range of journals in which T_{100} articles were published varied between 987 and 8. The *New England Journal of Medicine* had the highest IF (60.00) and highest *H*-index (987) among the journals in which the T_{100} articles were published. *New England Journal of Medicine* is a Q1 quartile journal (Table 2).

According to the level of evidence (SIGN50), 51% of T_{100} articles were at Level 2, 33% of T_{100} articles were at Level 4, 12% of T_{100} articles were Level 1, 3% of T_{100} articles were at Level 3, and 1% articles of T_{100} articles were at Level 5 (Table 3).

The top three social media platforms where the T_{100} articles are mentioned are presented in Figure 2. The first mentioned of the articles is on (n=55) Twitter, the second mentioned article is on News Outlet (n=30), and the third mentioned article is on Facebook pages (n=35). Twitter is the most popular social media network for mentioning articles.

The top three (first, second, third) and all research categories for each of the articles are presented in Figure 3. The first, second, and third research categories of articles are "Medical and Health Science", "Oncology and Carcinogenesis", and "Public Health and Health Services" respectively. "Medical and Health Science" was the research category for 40 articles.

Twitter geographical breakdown and Twitter demographical breakdown are presented in Figure 4 and Figure 5. The data were gathered from the profiles of Twitter users who shared these articles. Twitter demographic and Twitter geographical breakdown in the articles were classified into the first, second, and third with respect to the number of shares on Twitter. From the data in Figure 4, it is apparent that the first and the second Twitter geographical breakdown shows that United States is the country in which most of the social media posts of T_{100} articles were made, which was similar to the geographical breakdown of all Twitter uses. In addition, the third Twitter geographical breakdown tweets were mostly from the United Kingdom. According to Figure 5, the first Twitter demographic breakdown for which most tweets were made was member of the public, and the second and third Twitter demographic breakdown was mostly practitioners (doctors and other healthcare professionals).

There was a strong positive correlation between: Total Citations Score and Recent Citations Score ($r=0.940$; $p=0.001$) (Fig. 6). According to univariate linear regression analysis, 88% of variation in the Total Citation Score was explained by recent citations. A one unit increase in recent citations resulted in a 4.9 increase in Total Citation Score model to estimate Total Citations Score was:

$$Y_{\text{Total Citations Score}} = -36.9+4.9*X_{\text{Recent Citations Score}}$$

Discussion

The substance of scientific articles is disseminated using social media.[13] Altmetrics analyzes the number of mentions of an article in academic social networks, allowing researchers to determine how much attention an article receives and how frequently it is mentioned.[14]

The altmetric study by Goksoy and Bozkurt analyzed the top 50 most cited articles on gastric cancer; altmetric scores of between 0 and 211 were obtained in this publication.[15] Another altmetric study by Munnolli analyzed 25 articles on cancer, and the altmetric score ranged from 0–45 in this publication.[16] The altmetric study by Celik et al. researched the top 50 cited cancer articles with the highest altmetric scores; altmetric scores between 7 and 1709 were found in this publication.[7] All altmetric scores serve as an opportunity to appraise the association between altmetric scores

Table 1. Top 100 article by metrics (T100 list)

Rank	Title	Year	First author	Total Citation	Recent Citation	Altmetric Score
1	Antioxidants Accelerate Lung Cancer Progression in Mice	2014	Volkan I. Sayin	465	159	846
2	Oxidants, antioxidants and the current incurability of metastatic cancers	2013	Jim Watson	259	44	569
3	Activation of the NRF2 antioxidant program generates an imbalance in central carbon metabolism in cancer	2017	Volkan I. Sayin	92	74	468
4	BACH1 Stabilization by Antioxidants Stimulates Lung Cancer Metastasis	2019	Clotilde Wiel	112	112	197
5	The Promise and Perils of Antioxidants for Cancer Patients	2014	Elizabeth G. Phimister	116	42	187
6	Oxidative DNA damage, antioxidants, and cancer	1999	Andrew R. Collins	244	18	145
7	Efficacy of Adoptive T-cell Therapy Is Improved by Treatment with the Antioxidant N-Acetyl Cysteine, Which Limits Activation-Induced T-cell Death	2016	Matthew J Scheffel	27	18	127
8	Antioxidant activity of Coriandrum sativum and protection against DNA damage and cancer cell migration	2013	Esther LH Tang	40	14	118
9	Protective Role of Dietary Berries in Cancer	2016	Aleksandra S. Kristo	43	29	101
10	Dietary Inflammatory Index, Dietary Non- Enzymatic Antioxidant Capacity, and Colorectal and Breast Cancer Risk (MCC-Spain Study)	2019	Mireia Obón-Santacana	9	9	97
11	Antioxidant EnzymescMediate Survival of Breast Cancer Cells Deprived of Extracellular Matrix	2013	Calli A. Davison	76	35	93
12	Role of Antioxidant Lycopene in Cancer and Heart Disease	2000	A V Rao	382	54	93
13	Antioxidant supplementation and breast cancer prognosis in postmenopausal women undergoing chemotherapy and radiation therapy.	2019	Audrey Y Jung	26	26	88
14	Innovatively Therapeutic Strategy on Lung Cancer by Daily Drinking Antioxidative Plasmon- Induced Activated Water	2018	Chien-Kai Wang	4	3	88
15	Treating Cancer by Targeting Telomeres and Telomerase	2017	Marko Ivancich	49	31	86
16	Antioxidants and cancer	2011	Justin Stebbing	10	3	83
17	Dietary intake and blood concentrations of antioxidants and the risk of cardiovascular disease, total cancer, and all-cause mortality: a systematic review and dose-response meta-analysis of prospective studies	2018	Dagfinn Aune	59	59	82
18	Antioxidant supplements for preventing gastrointestinal cancers	2008	Goran Bjelakovic	113	18	77
19	The role of antioxidant versus pro-oxidant e!ects of green tea polyphenols in cancer prevention	2011	Sarah C. Forester	183	54	75
20	Antioxidant value and antiproliferative efficacy of mitragynine and a silane reduced analogue.	2014	Teik Beng Goh	6	3	74
21	Uric acid provides an antioxidant defense in humans against oxidant- and radical-caused aging and cancer: a hypothesis.	1981	B. N. Ames	2000	273	73
22	Should Supplemental Antioxidant Administration Be Avoided During Chemotherapy and Radiation Therapy?	2008	B. D. Lawenda	327	56	70
23	The Role of Antioxidants in Skin Cancer Prevention and Treatment	2014	Aleksandar Godic	137	55	69
24	Hinokitiol Inhibits Migration of A549 Lung Cancer Cells via Suppression of MMPs and Induction of Antioxidant Enzymes and Apoptosis	2018	Thanasekaran Jayakumar	11	10	63
25	IL-6 controls resistance to radiation by suppressing oxidative stress via the Nrf2-antioxidant pathway in oral squamous cell carcinoma	2016	Yuichiro Matsuoka	45	33	57
26	Cancer prevention by antioxidants.	2004	Hoyoku Nishino	51	7	57
27	Dietary Sulforaphane in Cancer Chemoprevention: The Role of Epigenetic Regulation and HDAC Inhibition	2015	Stephanie M. Tortorella	124	67	57
28	Telomere length, oxidative damage, antioxidants and breast cancer risk	2009	Jing Shen	106	20	56

Table 1. CONT.

Rank	Title	Year	First author	Total Citation	Recent Citation	Altmetric Score
29	Antioxidant supplements for prevention of gastrointestinal cancers: a systematic review and meta-analysis	2004	Goran Bjelakovic	462	34	53
30	Antioxidant activity of ginger extract as a daily supplement in cancer patients receiving adjuvant chemotherapy: a pilot study	2017	Kwanjit Danwilai	28	18	52
31	Dietary antioxidants and the aetiology of pancreatic cancer: a cohort study using data from food diaries and biomarkers	2012	Paul J R Banim	40	7	49
32	Antioxidant micronutrients and the risk of renal cell carcinoma in the Women's Health Initiative cohort	2014	Won Jin Ho	17	3	47
33	Inhibitory Effect of Antioxidant Extracts From Various Potatoes on the Proliferation of Human Colon and Liver Cancer Cells	2011	Quanyi Wang	27	8	46
34	Diet and Skin Cancer: The Potential Role of Dietary Antioxidants in Nonmelanoma Skin Cancer Prevention	2015	Rajani Katta	20	12	46
35	Surviving Antioxidant Supplements	2007	G. Bjelakovic	67	11	45
36	Effects of antioxidant supplements on cancer prevention: meta-analysis of randomized controlled trials	2010	S.-K. Myung	105	20	44
37	Efficacy of Kombucha Obtained from Green, Oolong, and Black Teas on Inhibition of Pathogenic Bacteria, Antioxidation, and Toxicity on Colorectal Cancer Cell Line	2019	Thida Kaewkod	8	8	41
38	Food Antioxidants and Their Anti-Inflammatory Properties: A Potential Role in Cardiovascular Diseases and Cancer Prevention	2016	Keith Griffiths	109	70	41
39	Antioxidant Supplementation Increases the Risk of Skin Cancers in Women but Not in Men	2007	Serge Hercberg	127	15	37
40	Role of antioxidants in cancer therapy	2013	Vanessa Fuchs-Tarlovsky	144	49	36
41	Cranberries and Cancer: An Update of Preclinical Studies Evaluating the Cancer Inhibitory Potential of Cranberry and Cranberry Derived Constituents	2016	Katherine Weh	24	17	35
42	Dietary Flavonoids as Cancer Chemopreventive Agents: An Updated Review of Human Studies	2019	Carmen Rodríguez-García	69	69	35
43	Plant Foods, Antioxidant Biomarkers, and the Risk of Cardiovascular Disease, Cancer, and Mortality: A Review of the Evidence	2019	Dagfinn Aune	17	17	35
44	Phenolic Composition, Antioxidant Capacity and In Vitro Cancer Cell Cytotoxicity of Nine Prickly Pear (Opuntia spp.) Juices	2009	R. A. Chavez-Santoscoy	115	26	34
45	Free radicals, metals and antioxidants in oxidative stress-induced cancer	2006	M. Valko	3800	718	33
46	Antioxidative effects of the spice cardamom against non-melanoma skin cancer by modulating nuclear factor erythroid-2-related factor 2 and NF-κB signalling pathways	2011	Ila Das	28	15	33
47	Camel milk lactoferrin reduces the proliferation of colorectal cancer cells and exerts antioxidant and DNA damage inhibitory activities	2013	Hosam M. Habib	63	22	32
48	An Antioxidant Response Phenotype Shared between Hereditary and Sporadic Type 2 Papillary Renal Cell Carcinoma	2011	Aikseng Ooi	284	75	32
49	Systematic review: primary and secondary prevention of gastrointestinal cancers with antioxidant supplements.	2008	G. Bjelakovic	71	6	31
50	Flavonoids from Artemisia annua L. as Antioxidants and Their Potential Synergism with Artemisinin against Malaria and Cancer	2010	Jorge F.S. Ferreira	250	86	30
51	New Insights into Oncogenic Transformation: Elevating Antioxidant and Nucleotide Levels Does the Trick	2021	Rushendhiran Kesavan	0	0	27

Table 1. CONT.

Rank	Title	Year	First author	Total Citation	Recent Citation	Altmetric Score
52	Antioxidant supplements for preventing gastrointestinal cancers	2004	G. Bjelakovic	48	4	27
53	Glutathione and Thioredoxin Antioxidant Pathways Synergize to Drive Cancer Initiation and Progression	2015	Isaac S. Harris	464	251	25
54	Prospective association between red and processed meat intakes and breast cancer risk: modulation by an antioxidant supplementation in the SU.VI.MAX randomized controlled trial	2014	C Camille Pouchieu	16	3	24
55	Impact of antioxidant supplementation on chemotherapeutic toxicity: A systematic review of the evidence from randomized controlled trials	2008	Keith I. Block	157	28	24
56	Antioxidant vitamins and mineral supplementation, life span expansion and cancer incidence: a critical commentary	2012	Piero Dolara	58	11	23
57	Use of antioxidant supplements during breast cancer treatment: a comprehensive review	2008	Heather Greenlee	70	6	23
58	Antioxidants as precision weapons in war against cancer chemotherapy induced toxicity – Exploring the armoury of obscurity	2018	Kanchanlata Singh,	52	47	23
59	Dietary iron intake and breast cancer risk: modulation by an antioxidant supplementation	2016	Abou Diallo,	16	10	23
60	The antioxidant and pro-oxidant activities of green tea polyphenols: A role in cancer prevention	2010	Joshua D.	490	139	23
61	Plant Foods, Antioxidants, and Prostate Cancer Risk: Findings From Case-Control Studies in Canada	1999	Meera G. Jain	208	13	23
62	Manganese Superoxide Dismutase Polymorphism, Prediagnostic Antioxidant Status, and Risk of Clinical Significant Prostate Cancer	2005	Haojie Li,	180	10	22
63	The Antioxidant Potency of Punica granatum L. Fruit Peel Reduces Cell Proliferation and Induces Apoptosis on Breast Cancer	2011	Miris Dikmen,	78	28	22
64	Antioxidants and breast cancer risk- a population-based case-control study in Canada	2011	Sai Yi Pan,	32	11	21
65	The Complex Interplay between Antioxidants and ROS in Cancer	2020	Isaac S.	37	37	21
66	Metastasized lung cancer suppression by Morinda citrifolia (Noni) leaf compared to Erlotinib via anti-inflammatory, endogenous antioxidant responses and apoptotic gene activation	2016	Swee-Ling Lim	11	6	21
67	Association between intake of antioxidants and pancreatic cancer risk: a meta-analysis	2016	Jiamin Chen	34	19	21
68	Incidence of skin cancers during 5-year follow-up after stopping antioxidant vitamins and mineral supplementation	2010	Khaled Ezzedine	34	4	20
69	Efficacy of Antioxidant Vitamins and Selenium Supplement in Prostate Cancer Prevention: A Meta-Analysis of Randomized Controlled Trials	2010	Lei Jiang	66	13	20
70	Red raspberries have antioxidant e!ects that play a minor role in the killing of stomach and colon cancer cells	2010	Jason God	14	4	19
71	Ketogenic diet combined with antioxidant N-acetylcysteine inhibits tumor growth in a Mouse model of anaplastic thyroid cancer	2020	Abha Aggarwal,	3	3	18
72	Antioxidant supplement use after breast cancer diagnosis and mortality in the Life After Cancer Epidemiology (LACE) cohort	2011	Heather Greenlee	54	15	18
73	Antioxidant enzymes change in different non-metastatic stages in tumoral and peritumoral tissues of colorectal cancer	2020	Auba Gaya-Bover,	4	4	18
74	Chemoprevention of cancer: Phenolic antioxidants (BHT, BHA)	1988	Gabriel Hocman	79	5	17

Table 1. CONT.

Rank	Title	Year	First author	Total Citation	Recent Citation	Altmetric Score
75	Paraoxonase-1 (PON1) induces metastatic potential and apoptosis escape via its antioxidative function in lung cancer cells	2017	Mark Borris D. Aldonza,	14	10	17
76	The e!ects of cranberry juice consumption on antioxidant status and biomarkers relating to heart disease and cancer in healthy human volunteers	2005	S. J. Duthie	218	36	17
77	Dietary Glucosinolates Sulforaphane, Phenethyl Isothiocyanate, Indole-3-Carbinol/3,3'- Diindolylmethane: Antioxidative Stress/In"ammation, Nrf2, Epigenetics/Epigenomics and In Vivo Cancer Chemopreventive E#cacy	2015	Francisco Fuentes	92	41	17
78	Effcacy of Antioxidant Supplementation in Reducing Primary Cancer Incidence and Mortality: Systematic Review and Meta-analysis	2008	Aditya Bardia	132	14	16
79	Serum Antioxidant Nutrients, Vitamin A, and Mortality in U.S. Adults	2013	Abhishek Goyal	51	16	16
80	Alpha lipoic acid and its antioxidant against cancer and diseases of central sensitization.	2013	Marisa Durand	4	1	16
81	Manganese Superoxide Dismutase in Cancer Preventio	2014	Delira Robbins	39	21	15
82	Effect of strength training and antioxidant supplementation on perceived and performance fatigability in breast cancer survivors: a randomized, double-blinded, placebo-controlled study	2020	Filipe Dinato de Lima	1	1	15
83	Evaluation of the antioxidant impact of ginger-based kombucha on the murine breast cancer model	2018	Samaneh Salafzoon	5	3	15
84	Intake of dietary antioxidants is inversely associated with biomarkers of oxidative stress among men with prostate cancer	2015	Terrence M. Vance	13	5	15
85	Preventive E!ects of Cocoa and Cocoa Antioxidants in Colon Cancer	2016	María Martín	19	12	15
86	E!ects of Vitamin Treatment or Supplements with Purported Antioxidant Properties on Skin Cancer Prevention: A Meta-Analysis of Randomized Controlled Trials	2011	Yoon Jung Chang	15	4	15
87	Antioxidant supplementation and cancer patients receiving curative-intent chemotherapy	2016	Peter J Smith	1	0	14
88	The balance between NRF2/GSH antioxidant mediated pathway and DNA repair modulates cisplatin resistance in lung cancer cells	2019	Matheus Molina Silva	21	21	14
89	Antioxidant Supplements and Risk of Breast Cancer Recurrence and Breast Cancer-Related Mortality Among Postmenopausal Women	2003	Aaron T. Fleischauer	54	6	14
90	Systematic Review of Intravenous Ascorbate in Cancer Clinical Trials	2018	Gina Nauman	36	32	14
91	Dietary Antioxidants and Prostate Cancer: A Review	2013	Terrence M.Vance	60	18	14
92	Antioxidant and cytotoxicity effect of rice bran phytic acid as an anticancer agent on ovarian, breast and liver cancer cell lines.	2011	Norhaizan ME	30	10	14
93	Running exercise may reduce risk for lung and liver cancer by inducing activity of antioxidant and phase II enzymes	1997	Karen Duncan	36	1	14
94	Insights on the Effects of Resveratrol and Some of Its Derivatives in Cancer and Autoimmunity: A Molecule with a Dual Activity	2020	Gianchecchi	10	10	14
95	Free radical scavenging, antioxidant and cancer chemoprevention by grape seed proanthocyanidin: An overview	2014	Debasis Bagchi	99	38	14
96	Antioxidative and Apoptotic Properties of Polyphenolic Extracts from Edible Part of Artichoke (Cynara scolymus L.) on Cultured Rat Hepatocytes and on Human Hepatoma Cells	2008	Stefania Miccadei	77	28	13
97	Cytotoxicity of ascorbate, lipoic acid, and other antioxidants in hollow fibre in vitro tumours	2001	J J Casciari	65	5	13
98	Effect of dietary genistein on Phase II and antioxidant enzymes in rat liver	2009	Wiegand H	49	5	13
99	Antioxidant polyphenols in cancer treatment: Friend, foe or foil?	2017	Gian Luigi Russo	62	47	12
100	Dietary Antioxidants and the Risk of Lung Cancer	1991	Paul Knekt	180	0	12

Table 2. Journals with top-100 articles, ranked according to the citations.

Journal name	Number of articles	IF*	Q category**	H index**
Antioxidants	6	4,520	Q1	33
Nutrition and Cancer	5	2,363	Q2	112
Cancer Research	3	9,130	Q1	434
American Journal of Clinical Nutrition	2	6,77	Q1	325
Scientific Reports	2	3,998	Q1	179
Cochrane database of systematic reviews	2	7,890	Q1	261
JNCI: Journal of the National Cancer Institute	2	12,589	Q1	348
British Journal of Cancer	2	5,791	Q1	224
Antioxidants & Redox Signaling	2	7,04	Q1	177
International Journal of Cancer	2	5,145	Q1	225
Cancer	2	5,742	Q1	292
Diseases	2	5,022	-	-
British Journal of Nutrition	2	3,334	Q1	178
Cancer Cell	2	26,602	Q1	316
European Journal of Nutrition	2	4,664	Q1	90
Oncotarget	2	3,71	Q1	108
International Journal of Biochemistry & Cell Biology	2	3,673	Q1	176
Science Translational Medicine	1	16,304	Q1	190
Open Biology	1	4,93	Q1	46
eLife	1	7,080	Q1	115
Cell	1	38.637	Q1	747
New England Journal of Medicine	1	74,699	Q1	987
BioEssays	1	4,725	Q1	178
Cancer Discovery	1	9,130	Q1	434
BMC Complementary and Alternative Medicine	1	3,03	Q2	80
Nutrients	1	4,546	Q1	93
The Journal of the American College of Nutrition	1	2,36	Q2	116
Lancet Oncology	1	33,752	Q1	305
Molecular Nutrition & Food Research	1	4,653	Q1	122
Asian Pacific Journal of Cancer Prevention	1	2,52	Q4	70
Proceedings of the National Academy of Sciences of the United States of America	1	9,412	Q1	737
Oxidative Medicine & Cellular Longetivity	1	5,076	Q1	66
International Journal of Molecular Sciences	1	4,556	Q1	140
Biofactors	1	4,734	Q1	90
The Lancet	1	60,392	Q1	747
Cancer Management and Research	1	2,886	Q3	35
Gut	1	19,819	Q1	27
Journal of Skin Cancer	1	-	Q3	8
Annals of Oncology	1	18,274	Q1	229
Microorganisms	1	4,167	Q2	224
Journal of Nutrition	1	4,281	Q1	254
Nutrition	1	3,42	Q2	135
Advances in Nutrition	1	7,24	Q1	78
Plant Foods for Human Nutrition	1	3,133	Q1	72
Chemico-Biological Interactions	1	2,577	Q1	115
Food Chemistry	1	6,306	Q1	242
Alimentary Pharmacology & Therapeutics	1	7,357	Q1	169
Molecules	1	3,267	Q2	131
Trends in Cancer	1	11,093	Q1	35

Table 2. CONT.

Journal name	Number of articles	IF*	Q category**	H index**
International Journal of Epidemiology	1	7,707	Q1	195
Breast Cancer Research and Treatment	1	3,940	Q1	148
Saudi Pharmaceutical Journal	1	2,879	Q1	42
Archives of Biochemistry & Biophysics	1	3,391	Q1	164
Journal of Medicinal Food	1	2,040	Q2	75
BMC Cancer	1	3,150	Q2	122
Trends in Cell Biology	1	16,041	Q1	228
Molecular and Cellular Biochemistry	1	2,795	Q2	119
International Journal of Food Sciences & Nutrition	1	3,483	Q2	68
European Journal of Cancer	1	7,275	Q1	205
Nutrition Research	1	3,647	Q2	86
Surgery	1	3,356	Q1	156
Current Pharmacology Reports	1	2,19	Q3	17
Mayo Clinic Proceedings	1	6,942	Q1	171
Cancer Epidemiology, Biomarkers & Prevention	1	4,344	Q1	187
Nutrición Hospitalaria	1	0,888	Q3	48
Applied Physiology, Nutrition, and Metabolism	1	2,522	Q1	84
Journal of Complementary and Integrative Medicine	1	1,21	Q3	18
Dermatology	1	3,072	Q1	89
Medical Journal of Australia	1	5,438	Q2	127
Malaysian Journal of Nutrition	1	0,27	Q4	25
Cancer Letters	1	7,360	Q1	172
Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis	1	3,680	Q1	156
Cancer Genomics & Proteomics	1	3,28	Q1	36
Seminars in Cancer Biology	1	11,09	Q1	140
American Journal of Epidemiology	1	4,526	Q1	247

* IF: Impact Factor, 2018 Journal Citation Reports, Web of Science Group, 2019; **2020 Scimago Journal and Country Rank.

and citation status of the publications. Generally, there has not been correlation between altmetric scores and citation time of the publications.[17] For example, in our study, an article with 3800 citations was ranked 45th in the altmetric score order among 100 articles. Conversely, the article that was 3rd in the altmetric score order had just 92 total citations. Therefore, in our study, there was no correlation between altmetric score and total citations.

There was a correlation between Altmetric score and impact factor (IF).[18, 19] In our research, the articles with a high altmetric score were published in journals with a high impact factor. The journals with higher impact factors can be more reliability to result in the sharing of a large number of posts in social media. Thus, articles are promoted in newspapers, blogs, and social media faster and efficiently than other journals.[13]

The level of evidence was used to rank the power of results acquired from scientific research. There is wide agreement on the relative power of large-scale, epidemiological studies.[20] In our study, more than half the 100 articles that we examined were Level 2. This may be due to the fact that more randomized controlled trials on oxidative stress–cancer have been published.

In our study, Twitter, news outlets, and Facebook were the social media networks that most often mentioned articles, in that order. In science and research, social media is proposed as an alternative to traditional power structures.[21] An altmetric study by Kolahi and Khazaei found that Twitter was far more popular than Facebook among Altmetric's top 50 dental articles.[22] Radhakrishnan and Baskaran used Altmetric to examine articles in the phytochemistry literature. They discovered that the majority of publications were shared via social media, especially Twitter.[23] As a result, it is acceptable for T_{100} articles to be mentioned on various social media networks.

When we examined the research categories of the T_{100} articles in our study, they were found to be published in the categories of "Medical and Health Science", "Oncology and

Table 3. Level of evidence on antioxidants and cancer of the top 100 articles

Main Subject	Level 1	Level 2	Level 3	Level 4	Level 5	Total
Antioxidant- Cancer	5	9	1	20		35
Antioxidant- Lung Cancer		8				8
Antioxidant- Breast Cancer	1	9	1	1		12
Antioxidant- Gastrointestinal cancers	2			2		4
Antioxidant- Skin Cancer	2	2		2		6
Antioxidant- Cancer Chemopreventive		2		5	1	8
Antioxidant-Prostate Cancer	1	2	1	1		5
Antioxidant-Pancreatic cancer	1	1				2
Antioxidant-Metastatic Cancers		1				1
Antioxidant- Cancer Chemopreventive				1		1
Antioxidant- Colorectal and Breast Cancer		1				1
Antioxidant - T-cell Therapy		1				1
Antioxidant-oral squamous cell carcinoma		1				1
Antioxidant-Renal Cell Carcinoma		2				2
Antioxidant- Colon and Liver Cancer		1				1
Antioxidation- Colorectal Cancer Cell		3				3
Antioxidant- Oncogenic Transformation		1				1
Antioxidant-Stomach and Colon Cancer		1				1
Antioxidant-Anaplastic thyroid Cancer		1				1
Antioxidant- Colon Cancer				1		1
Antioxidant Effects- Ovarian, Breast and Liver Cancer Cells		1				1
Antioxidant- Lung and Liver Cancers		1				1
Antioxidant- Liver Cancer		2				2
Antioxidant- Tumor Cells		1				1

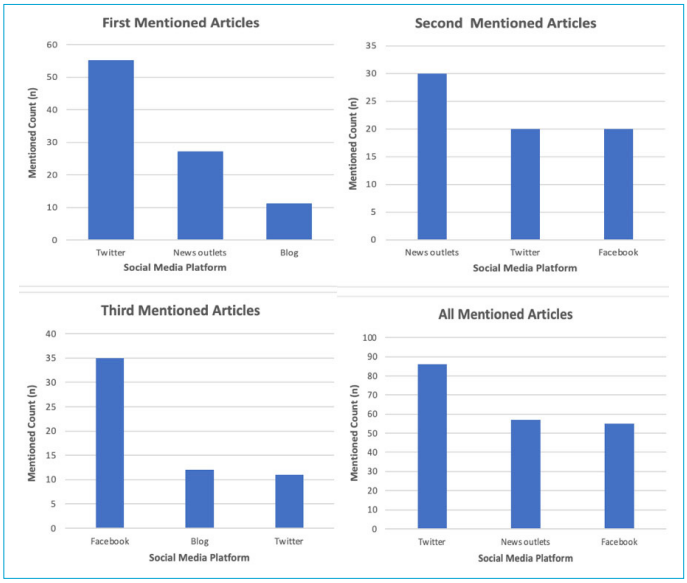

Figure 2. Social media platforms where the T_{100} articles are mentioned.

Carcinogenesis", and "Public Health and Health Services". When compared with other articles, medical and health science articles received a significant amount of Twitter attention. This could be interpreted as a sign of personal relevance to the audience.[24] Therefore, these research categories are also compatible with our antioxidant-cancer altmetric analysis.

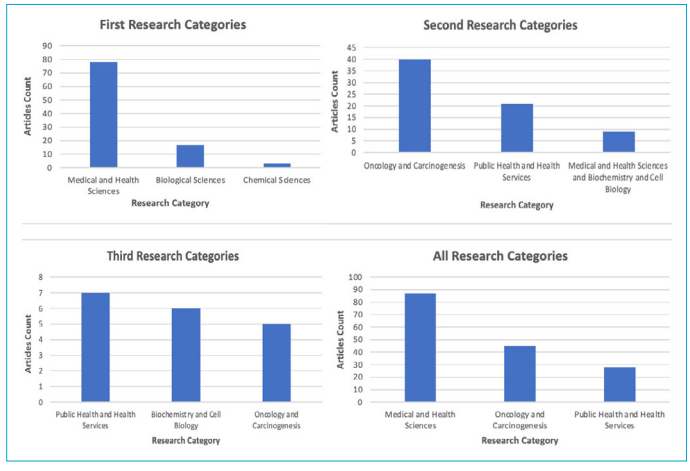

Figure 3. Research categories of T_{100} articles.

Geographical and demographical breakdown profiles demonstrate who is tweeting on antioxidants and cancer. The geographical breakdown can be determined from a map of Twitter and a basic analysis obtained from Twitter users who share an article anywhere in the world.[25]

In our study, the United States dominated over other coun-

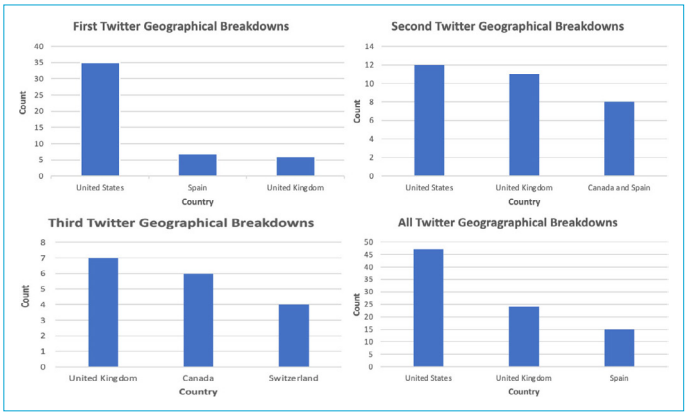

Figure 4. Twitter geographical breakdowns of T_{100} articles.

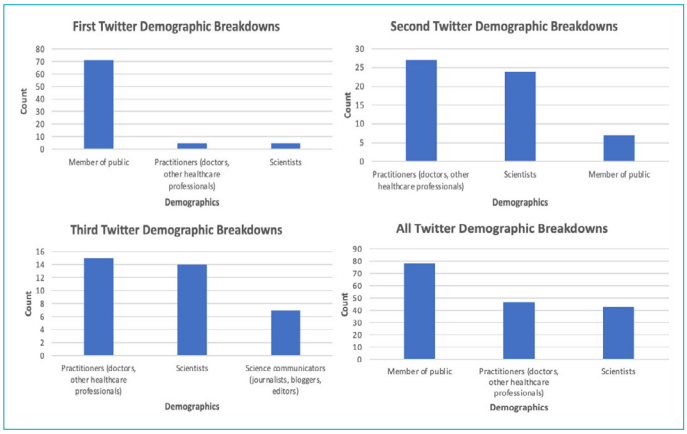

Figure 5. Twitter demographical breakdowns of T_{100} articles.

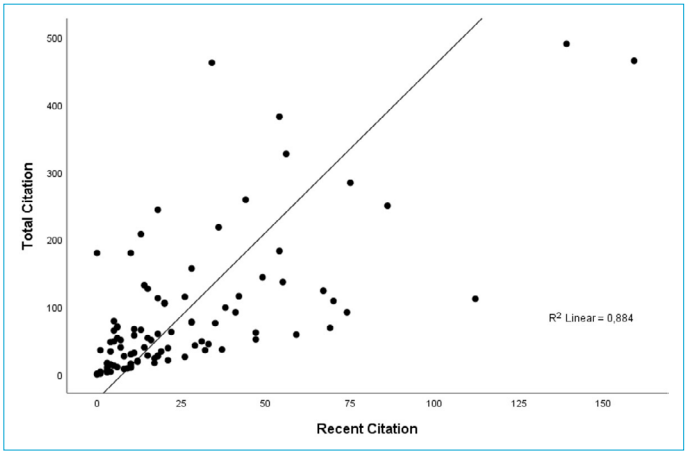

Figure 6. Total citations Score & Recent citations score scater plot.

tries in the Twitter geographical breakdown. The microblogging service Twitter is extremely popular in the United States, with 69.3 million members as of January 2021.[26] Additionally, in the United States, a quarter of social media users (26%) follow scientific accounts; these users are considerably more likely to click through to articles on science postings and perceive social media to be an essential source of science news.[27]

From the Twitter demographic breakdown, members of the public shared the majority of tweets on antioxidant and cancer. According to web respondents on the American Trends Panel in the United States, topics of great interest for online adults included health and medicine, government and politics, and science and technology. Some 37% of online adults view "health and medicine" as one of the most interesting topics, whereas 32% find "science and technology" to be one of the most interesting.[27] As seen by these findings, the public's interest in science and technology can be expanded through social media.

Conclusion

The remarkable growth of the internet into a social web has necessitated the use of more diversified and complex techniques of impact analysis to assess the impact of research beyond traditional research.[28] Furthermore, the use of social media to disseminate the messages of scientific publications is becoming more common.[29] We present the first assessment of social media attention on the 100 articles on antioxidant and cancer with the highest Altmetric Attention Score found in by examining the Altmetric.com database. Our findings can provide a preliminary view into the social, clinical, and academic impacts of antioxidant and cancer research; moreover, thanks to studies of this nature, scholars will be able to adjust to the changing paradigm of assessing effect and quality in the digital era, and compare and benchmark their progress.

Disclosures

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

Authorship Contributions: Concept – G.V.; Design – G.V., F.H., M.D.; Supervision – G.V., M.D.; Materials – G.V., M.D., F.H.; Data collection &/or processing – G.V., T.G., M.K.; Analysis and/or interpretation – G.V., T.G., M.K.; Literature search – G.V.; Writing – G.V., F.H., M.D., T.G.; Critical review – G.V., M.K.

References

1. Athreya K, Xavier MF. Antioxidants in the Treatment of Cancer. Nutr Cancer 2017;69:1099–104.
2. Valko M, Rhodes CJ, Moncol J, Izakovic M, Mazur M. Free radicals, metals and antioxidants in oxidative stress-induced cancer. Chem Biol Interact 2006;160:1–40.
3. Matés JM, Pérez-Gómez C, Núñez de Castro I. Antioxidant enzymes and human diseases. Clin Biochem 1999;32:595–603.
4. McCall MR, Frei B. Can antioxidant vitamins materially reduce oxidative damage in humans? Free Radic Biol Med 1999;26:1034–53.
5. Barazesh S. Probing Question: How do antioxidants work?. Retrieved from https://www.psu.edu/news/research/story/

probing-question-how-do-antioxidants-work/. Accessed Jan 12, 2021.
6. Klaunig JE. Oxidative stress and cancer. Curr Pharm Des 2018;24:4771–8.
7. Celik E, Dokur M, Uysal BB, Samancı NS, Demirelli FH. Comparison of attention for cancer research on social media versus academia: an altmetric score analysis. UHOD 2020;30:32–42.
8. Hassona Y, Qutachi T, Dardas L, Alrashdan MS, Sawair F. The online attention to oral cancer research: An Altmetric analysis. Oral Dis 2019;25:1502–10.
9. Warren HR, Raison N, Dasgupta P. The rise of altmetrics. JAMA 2017;317:131–2.
10. Kolahi J. Altmetrics: A new emerging issue for dental research scientists. Dent Hypotheses 2015;6:1–2.
11. Melero R. Altmetrics - a complement to conventional metrics. Biochem Med (Zagreb) 2015;25:152–60.
12. Brigham TJ. An introduction to altmetrics. Med Ref Serv Q 2014;33:438–47.
13. Araujo AC, Vanin AA, Nascimento DP, Gonzalez GZ, Costa LOP. What are the variables associated with Altmetric scores? Syst Rev 2021;10:193.
14. Abacı A. Scientific competition, impact factor, and Altmetrics. Anatol J Cardiol 2017;18:313.
15. Goksoy B, Bozkurt H. Social attention of the top 50 scientific articles on gastric cancer: Bibliometric and altmetric analysis. J BUON 2020;25:2322–31.
16. Munnolli S, Pujar S. The Impact of indian cancer research in social media: a study using altmetric explorer. Emerging Trends and Issues in Scientometrics, Informetrics and Webometrics. New Delhi: Institute of Economic Growth; 2015.
17. Huang W, Wang P, Wu Q. A correlation comparison between Altmetric Attention Scores and citations for six PLOS journals. PLos One 2018;13:e0194962.
18. Araujo AC, Nascimento DP, Gonzalez GZ, Maher CG, Costa LOP. Impact of low back pain clinical trials measured by the altmetric score: cross-sectional study. J Med Internet Res 2018;20:e86.
19. Dinsmore A, Allen L, Dolby K. Alternative perspectives on impact: the potential of ALMs and altmetrics to inform funders about research impact. PLos Biol 2014;12:e1002003.
20. Hierarchy of evidence. Available at: https://en.wikipedia.org/wiki/Hierarchy_of_evidence#cite_note-28. Accessed Jan 14, 2021.
21. Wetsman N. How Twitter is changing medical research. Nat Med 2020;26:11–3.
22. Kolahi J, Khazaei S. Altmetric: Top 50 dental articles in 2014. Br Dent J 2016;220:569–74.
23. Radhakrishnan S, Baskaran C. Phytochemistry literature: an altmetrics analysis. Library Philosophy and Practice 2020:4048.
24. Vainio J, Holmberg K. Highly tweeted science articles: who tweets them? An analysis of Twitter user profile descriptions. Scientometrics 2017;112:345–66.
25. Stephen G. Altmetric for top three covid-19 research articles published in 2020 - an overview. Library Philosophy and Practice 2020:5786.
26. Leading countries based on number of Twitter users as of October 2021. Available at: https://www.statista.com/statistics/242606/number-of-active-twitter-users-in-selected-countries/. Accessed Jan 18, 2021.
27. Funk C, Gottfried J, Mitchell A. Science News and Information Today. Available at: https://www.pewresearch.org/journalism/2017/09/20/science-news-and-information-today/. Accessed Jan 18, 2021.
28. Dardas LA, Woodward A, Scott J, Xu H, Sawair FA. Measuring the social impact of nursing research: An insight into altmetrics. J Adv Nurs 2019;75:1394–405.
29. Sathianathen NJ, Lane Iii R, Murphy DG, Loeb S, Bakker C, Lamb AD, et al. Social media coverage of scientific articles immediately after publication predicts subsequent citations - #SoME_Impact Score: observational analysis. J Med Internet Res 2020;22:e12288.