Original Article

A bibliometric analysis of the 100 top-cited articles on global malnutrition indexed in Web of Science

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Background: This study explored top 100 most-cited articles on global malnutrition. It presents advancement of malnutrition research effort globally.

Methods: A comprehensive Web of Science database search was performed using Medical Subject Headings (MeSH) with search terms "title Malnutrition*" OR "undernutrition*" OR "Nutrition Deficiency*" OR "Nutrition disorders*" OR "malnourishment". The result was analyzed using SPSS, HistCite, Bibliometrix, and VOSviewer.

Results: The top 100 most-cited malnutrition articles were published between 1940 and 2019. The number of citations ranges from 235 to 2,890, with a median of 342.5, and the interquartile range (IQR) was 195.5. The United States was the most contributing country, World Health Organization (WHO) has more publications on malnutrition than any other institution, and *Lancet* was the most productive journal. Robert E Black from Johns Hopkins University, School of Public Health with an h-index of 5 and Mercedes de Onis from the Department of Nutrition for Health and Development, WHO with an h-index of 5 were the most prolific authors in the list. The study revealed a significant correlation between the total number of citations and the journal h-index (r=0.7573, P<0.0001), the number of years since publication (r=0.7881, P<0.0001), the number of countries (r=0.8982, P<0.0001), and the number of authors (r=0.4601, P<0.0001), and institutions (r=0.5948, P<0.0001) involved in the publication.

Conclusions: This study provides insight into the historical advancements reflected by the top-cited studies on malnutrition, the leading countries, journals, institutions, and authors, and frequently occurring keywords. It provides insight for readers and health policy-makers in evaluating malnutrition research output.

Keywords: Bibliometric analysis; malnutrition; VOSviewer; Web of Science

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Introduction

Malnutrition is a condition that arises from a cellular imbalance between the energy, nutrients supply, and the body's demand (1). It includes various forms of deficiency, excess or imbalance in energy and nutrients, and the most common types are undernutrition, evidenced in stunting and wasting, obesity, and micronutrient deficiencies such as vitamin A, iron, or iodine deficiencies. It is a severe public health challenge that threatens humans of all ages and creates vulnerabilities for other health, social and mental issues. For instance, undernutrition is a significant contributor to under-five mortality (2). The World Health Organization (WHO) referred to malnutrition as a "double burden" due to the coexistence of other health conditions and its simultaneous manifestation in different forms (3,4).

In specifics, malnutrition occurs as maternal and child undernutrition (5), imbalance malnutrition evidence in obesity and metabolism syndromes (6,7). In other dimensions, illness may also induce malnutrition, especially among kidney patients (8), among different prevalence that subsequently causes adverse health outcomes. Literature has expanded on protein-calorie malnutrition in chronic renal failure caused by illness-induced anorexia (IIA), an adaptive, protective response for injury elimination (9). Concurrently, nutrition and the immune system are vital components that mediate each other so much that when there is malnutrition, the immune response in the human body is grossly affected (10). Malnutrition also prevails as a comorbidity in persons with liver diseases (11) and a risk factor for small cerebral vessel disease and cognitive decline in peritoneal dialysis patients (12).

A global estimation of malnutrition prevalence in 2019 estimated that more than 820 million people were undernourished globally, and 4 million deaths were attributed to obesity (13). Although overnutrition is relatively a recent rising occurrence, undernutrition, on the other hand, has been a concern for a longer time hence its presence on the agenda of the main goals set to be achieved by 2030 by the United Nations. Goal 2 of the Sustainable Development Goals (SDG) is dedicated to attaining Zero Hunger and aims to end hunger, achieve food security and improved nutrition and promote sustainable agriculture (14). Over the past years, a growing literature has focused on understanding the causes (15,16), consequences (16,17), and possible solutions for malnutrition (18).

More recently, the universal burden of malnutrition has aggravated economic and social global inequalities, thereby bringing the intervention achievement to unacceptably slow progress. According to the global nutrition report, the slow progress of reducing some of the commonalities of malnutrition subsequently means about 88% of global country representation struggle with at least one form of malnutrition, and 29% have severe triple forms of malnutrition (19). The disproportionality in the prevalence of malnutrition globally calls for a thorough appraisal of research progress to address the persisting problem's influential factors. Therefore, this study unraveled the geographical concentration of research contribution on malnutrition (6).

This exposition is one approach that may foster the understanding of malnutrition intervention and possibly inform future policy frameworks. Bibliometrics analytical technique applies the quantitative investigation of indicators such as publication count, citations, impact factor, and co-citations to understand the different aspects of research output (18,19). The bibliometric analytical technique has consistently supported researchers in numerous research fields, including clinicians, governments, and general practitioners, in facilitating the monitoring of improvements and developing public health policies (20). Nevertheless, a search in the Web of Sciences databases revealed a dearth of scientific evidence on the bibliometric analysis on malnutrition that can support the global mediation of the disease. Therefore, this paper aims to evaluate the 100 top-cited scientific researches on global malnutrition by presenting, baseline line date of top articles, hot topics in the top-cited articles, authorship and their affiliation, and the corresponding authors' country of origin. In scope, the study objective is to access the top 100 articles on malnutrition to accentuate top research trends on malnutrition, centering on the total of publications spanning over a century, researchers, countries, institutions, and collaborations. The other objective is to analyze the most productive country and institution, research categories, frequency analysis, top 100 authors keywords, and factors affecting the number of citations of top 100 malnutrition research.

Methods

Search strategy

To identify the top 100 cited documents malnutrition-related literature, we performed our search through the Web

of Sciences (WoS) database (https://apps.webofknowledge.com/) database (updated on 20 February 19, 2021) by two researchers to avoid the database's daily update. First, a comprehensive search was conducted to identify the main heading terms and relevant entry term(s) indexed Medical Subject Headings (MeSH), which is available on (https://meshb-prev.nlm.nih.gov/search). Then, a Boolean search was conducted using the terms in the title ("malnutrition*" OR "Undernutrition" OR "Nutrition Deficiency" OR "Nutrition disorders" OR "malnourishment") with the largest time timespan allowed through the WoS ("all years [1900-2020]") with aiming to cover all the potential articles (20). Documents Indexes: ("Science Citation Index Expanded") and ("Social Sciences Citation Index"). Regardless of document type and language: only English published documents were included. We limited our results to full research articles and reviews sorted by the number of citations. Other document types were excluded from the analysis. As a result of a comprehensive search, a total of 10,100 documents related to malnutrition were the subject of further analysis (20). For further analysis, a list of top 100 articles was created by sorting all the retrieved items according to the citations score.

In addition to identifying the top 100 most-cited document on malnutrition-related literature based on the citation, two independent reviewers (TH Musa and TY Akintunde) evaluated the yielded title to compile a list of the top 100 most-cited articles of malnutrition and ensure that only relevant auricles were included. Finally, the top 100 selected articles were downloaded in plain text format and tab-delimited (win) format for further analysis. There is no ethical approval required, and bibliometric analysis and the data were downloaded from the public databases.

Bibliometric indicators and mapping

While assessing the articles and journals, the following information was extracted from the 100 articles: (I) title of publications; (II) year of publication; (III) number of total citations received from each publication; (IV) authorship details; (V) document type; (VI) institution; (VII) journals title; (VIII) document type; (XI) country of an article based on single country publications (SCP) and multiple country publications (MCP); (X) journal impact factors was obtained from Journal Citation Reports (JCR) © Ranking: 2019; (XI) furthermore, authors or journal h-index and g-index level metric was calculated to measure both the productivity and citation impact of the publications of a scientist or scholar (21-27). In addition to the keyword analysis which includes the frequency distribution of the authors "keywords" [Keywords (DE)], and the frequency distribution of keywords associated to the document by Clarivate Analytics Web of Science [Keywords Plus (ID)] (23). On the other hand, the scientific collaboration on the social process by which two or more researchers on malnutrition are working together as collaborators sharing their intellectual and material resources to produce new scientific knowledge in research related to global malnutrition (28).

Statistical analysis

Network analysis collaboration networks amongst authors, countries, and keywords were created using VOSviewer software (29). Bibliometrix (an R package) (23), GraphPad Prism 5 (30) were used for frequency analysis and data visualization. Given the distribution of variables and the presence of outliers, we preferred to use the median, range, and interquartile range (IQR) to describe some variables since these measures are less affected by extreme values (22,31). Pearson correlation coefficient was calculated using the Spearman correlation coefficient (r) to examine the association between citation times and the study variables. A P value of less than 0.05 was considered statistically significant.

Results

Characteristics of metadata

The basic information on the metadata is presented in *Table 1*. The analysis shows that 57 journals have contributed, and 548 authors participated. The mean number of citations in the top 100 articles was 466, median 342.5; range from 235 to 2,890, and the IQR was 195.5. The average number of citations in a single year per document was 27.55. The top 100 cited articles include 78 research articles and 22 review papers. The descriptive analysis of the top 100 articles is shown in Table S1.

Annual trend and total citations

While using the algorithm search strategy, the search in the WoS database for 1900 to 2020 produced 10,100 articles on malnutrition. The top 100 most-cited articles were identified from this collection and found to have been published between 1940 and 2019. Their various

Table 1 Main information about the bibliographic collection

Description	Results
Timespan	1940–2019
Sources (journals, books, etc.)	57
Documents	100
Average years from publication	25.9
Average citations per document	466.6
Average citations per year per doc	27.55
References	5,661
Document types	
Article	78
Review	22
Document contents	
Keywords Plus (ID)[a]	442
Author's keywords (DE)[b]	237
Authors	
Authors	548
Author appearances[c]	623
Authors of single-authored documents	5
Authors of multi-authored documents	543
Authors collaboration	
Single-authored documents	5
Documents per author	0.182
Authors per document	5.48
Co-authors per documents	6.23
Collaboration index (CI)[d]	5.72

[a], frequency distribution of keywords associated with the document by Clarivate Analytics Web of Science; [b], frequency distribution of the authors' "keywords"; [c], number of author appearances; [d], the scientific collaboration on the social process by which two or more researchers to produce an article.

characteristics were analyzed based on the total number of articles per year and total citation score in *Figure 1*.

Authorship and affiliations analysis

The most contributing authors with h-index ≥3 were identified. Table S2 shows the top 17 authors ranked by h-index and author ranking (1st author, 2nd author, and 3rd author). The most contributing author was Robert E. Black from Johns Hopkins University, School of Public Health, Baltimore, USA, with the highest publication count and the highest h-Index of 5, and total citations reported [7,700]. The second top author is Mercedes de Onis from the Department of Nutrition for Health and Development, WHO, Geneva, Switzerland, with h-index of 5, and total citation reported [6,761], among the reported list.

Most productive countries

Table 2 shows the top-cited articles in terms of country collaborations. The 100 most-cited malnutrition articles originated from 18 countries, of which nine countries originated from more than two articles. The USA was the most productive with 33 articles contributions, followed by the UK with seven articles. Based on the total number of times each manuscript has been cited, the USA, Brazil, and Switzerland were the leading contributing countries on malnutrition publications.

Most productive journals

The analysis of the publishing journals with more than three articles represented in the top 100 shown in *Table 3* reveals that *Lancet* is the top leading journal with h-index (12), followed by *Clinical Nutrition* with h-index of 8, and the *American Journal of Clinical Nutrition* with h-index of 5. Also, journals that published more than three articles belong to the first quartile range (Q1).

Most productive institutions and research categories

In *Table 4*, the WHO was the leading organization in malnutrition research, followed by Johns Hopkins University and the University of Sao Paulo. According to the categories of the top 100 most-cited articles on malnutrition, almost half of articles were published in general and internal medicine (n=24) and nutrition & dietetics (n=24). Other common categories include pediatrics (n=8), public, environmental & occupational health (n=7), urology & nephrology (n=6) among others.

Network analysis for co-authorship and countries

The network analysis between co-authorship and countries visualize and show the network's analysis based on the Total Link Strength (TLS) was conducted using VOSviewer software. Among the reported countries, a minimum of two

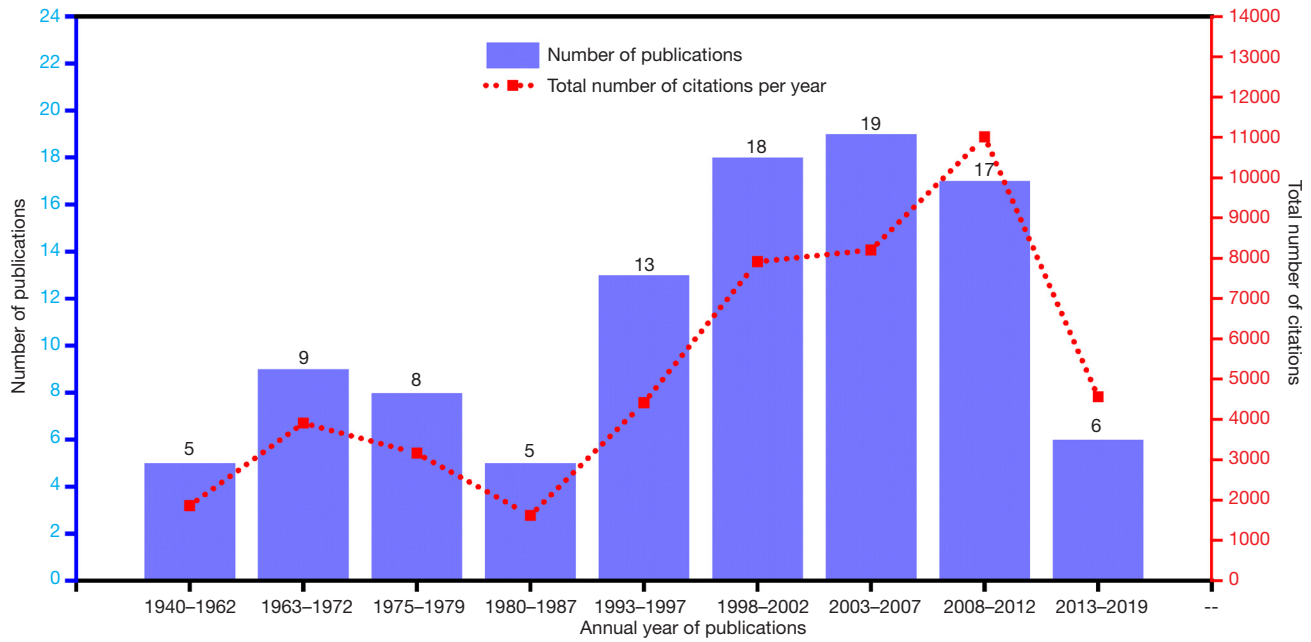

Figure 1 Annual trend of the number of publication on malnutrition top 100 articles and total number of citations by year.

Table 2 Corresponding author's country that leads one or more of the 100 top-cited studies of malnutrition

SCR	Country (n=18)	NP	NP per GDP	TC[a]	Country collaborations[b]	GDP (US$)	SCP	MCP
1	USA	33	1.540	17,403	33	21.433 trillion	17	16
2	UK	7	2.474	3,345	24	2.829 trillion	6	1
3	Sweden	6	0.011	3,239	16	530.884 billion	3	3
4	Germany	5	1.295	2,255	16	3.861 trillion	1	4
5	Australia	4	0.046	1,456	19	87.799 trillion	2	2
6	Brazil	4	2.174	3,274	25	1.840 trillion	3	1
7	Switzerland	4	0.006	1,465	14	703.082 billion	2	2
8	France	2	0.736	823	9	2.716 trillion	1	1
9	Netherlands	2	0.002	522	23	907.051 billion	2	0

[a], the number of times each manuscript has been cited; [b], the intra-country (SCP) and inter-country (MCP) collaboration indices. SCR, standard competition ranking; NP, number of publications; TC, total citation; GDP, gross domestic product; SCP, single country publications; MCP, multiple country publications.

instances of the country was required to meet the search criteria, and 25 countries only met the thresholds". In cluster 3, the USA (TLS =75), followed by Switzerland (TLS =27), France (TLS =17), Pakistan (TLS =11), and Spain (TLS =3). In cluster1, Netherlands (TLS =42), Germany (TLS =36), Sweden (TLS =29), and Thailand (TLS =16), and in cluster 3, India (TLS =24), and Colombia (TLS =3) as presented in *Figure 2A*. For co-authorship analysis, with a minimum of two instances of authorship required to meet the search criteria, and 40 authors only met the thresholds". For each of the 40 authors, the co-authorship links' total strength was calculated, and authors with the greatest total link strength were selected and presented in two clusters. The first cluster includes: Anders Alvestrand, Jonas Bergstrom, Jose C. Divino-Filho, Alberto Gutierrez with each (TLS =11), and the second cluster includes:

Table 3 Journals that published three or more of the 100 top-cited studies in malnutrition

SCR	Source	h-index	g-index	TC	NP	IF (2019)	Q
1	*Lancet*	12	12	11,758	12	60.39	Q1
2	*Clinical Nutrition*	8	8	3,807	8	6.36	Q1
3	*American Journal of Clinical Nutrition*	5	5	1,734	5	6.766	Q1
4	*Bulletin of the World Health Organization*	4	4	1,213	4	6.96	Q1
5	*Journal of Pediatrics*	4	4	1,221	4	3.7	Q1
6	*Nutrition*	4	4	1,306	4	3.639	Q2
7	*American Journal of Kidney Diseases*	3	3	1,209	3	6.618	Q1
8	*Jama-Journal of the American Medical Association*	3	3	1,556	3	45.54	Q1
9	*Neuroscience and Biobehavioral Reviews*	3	3	1,047	3	8.329	Q1

SCR, standard competition ranking; Q, journal quartile range; TC, total number of citations reported per documents; NP, number of articles.

Table 4 Top 10 institutions publishing 3 or more of the 100 most-cited on malnutrition papers and research categories with 2 or more of the 100 most-cited papers

SCR	Institutions	NP	Research category	NP
1	World Health Organization (WHO)	7	General and internal medicine	24
2	Johns Hopkins University	6	Nutrition & dietetics	24
3	Universidade de São Paulo	5	Pediatrics	8
4	Cornell University	4	Public, environmental & occupational health	7
5	Emory University	4	Urology & nephrology	6
6	University of Pennsylvania	4	Behavioural sciences; neurosciences & neurology	3
7	World Bank	4	Endocrinology & metabolism	3
8	Karolinska University Hospital	3	Geriatrics & gerontology	3
9	Johns Hopkins Bloomberg School of Public Health	3	Life sciences & biomedicine-other topics	2
10	The London School of Hygiene and Tropical Medicine	3	Surgery	2

SCR, standard competition ranking; NP, number of articles by first author institution.

Bengt Lindholm (TLS =14), A. Rashid Qureshi (TLS =14), Olof Heimburger (TLS =10), and Peter Stenvinkel (TLS =4) as shown in *Figure 2B*.

WordCloud of keywords analysis

The analysis of the top 100 keywords was visualized by using WordCloud analysis, as shown in *Figure 3*. For example, the most distribution of keywords associated with the document of malnutrition by Clarivate Analytics Web of Science [Keywords plus (ID)] is as follow: nutritional-status (n=12), risk (n=11), mortality (n=7), developing-countries (n=5), blood pressure (n=4), cardiovascular disease (n=4), disease (n=4), and growth (n=4).

Factors affecting the number of citations

The correlation analysis of possible factors influencing citations in malnutrition research articles is presented in *Table 5*. The significant correlations were found between the number of citations and journal h-index (r=0.7573, P<0.0001), year science publications (r=0.7881, P<0.0001), number of countries (r=0.8982, P<0.0001), and number of authors (r=0.4601, P<0.0001), and institution (r=0.5948, P<0.0001).

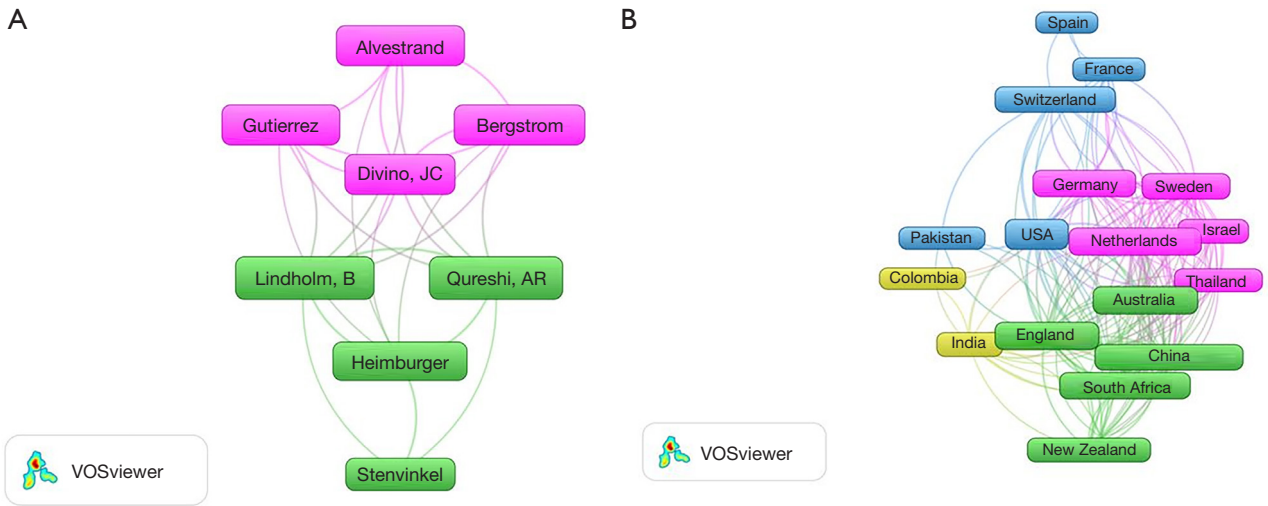

Figure 2 Co-authorship analysis of authors (A), and countries (B) based on the total length strength (TLS).

Figure 3 Frequency analysis of the Keywords Plus (ID).

Table 5 Factors that affecting the number of citations in malnutrition research production

Factor	Spearmen's (r)	P value
Journal h-index	0.7573	<0.0001
Journal impact factors (2019)	−0.03450	0.9484
Years since publications	0.7881	<0.0001
Number of countries	0.8982	<0.0001
Number of authors	0.4601	<0.0001
Institution	0.5948	<0.0001

Discussion

The bibliometric analysis of the top 100 most-cited articles in malnutrition research adopted the methodology to examine malnutrition research trends and identify the topmost contributors to malnutrition-related research. The goal is to provide researchers with an overview and snapshot of the critical areas, the growth, the directions, and the development of malnutrition research output. The top 100 most-cited articles were published between 1940 and 2019. The analysis revealed that citations began to increase for malnutrition research in early 2000. In the last two decades, article production's growth was accelerated, suggesting more significant attention to malnutrition-related domains and subsequently increases publications among researchers. With an increasing research output, a substantial peak citation period in 2008 corresponding with the period inaugural publication of *Lancet* Maternal and Child Undernutrition series was published. Subsequently, the three top most-cited articles found in the bibliometric analysis were from the *Lancet* Maternal and Child Undernutrition, when malnutrition was considered a critical health condition that necessitates urgent global attention and intervention. The introduction of the series came due to the child mortality prevalence estimation of 1 in 3 children global death recorded (32). The success of the inaugural issue on maternal and child malnutrition is further evident in the total number of citations reported in the bibliometric analysis, which facilitated rapid information sharing and guidance for ensuing researches that followed.

The evolution of malnutrition research publication presents an insight into global research focus over the last century. For instance, attention was given to surgical patients in the early stages of malnutrition research pieces

of evidence in the drug metabolism keywords between 1940 and 1995 and remain consistent until 2005 along with tumor-necrosis factors. Similarly, anthropometric indicators of malnutrition also came to focus in these periods and, more importantly, the shift of attention to the developing countries. Hence the health implication of malnutrition in developing countries gained prominence. In these periods of 2006 to 2019, there were clinical studies on mice, young and children research, risk factors, and index studies. Also, chronic renal failure problem was in the empirical discourse, and attention was increased from 1996 to 2019 on kidney patients' nutritional status and the impact of malnutrition.

The evidence from the keyword analysis conforms with existing literature on the prevalence of malnutrition in developing countries as evidence in "developing countries" numerous occurrences. This evidence further accentuates the corroboration that most malnutrition episodes originate from developing countries (19,33). However, "Nutritional-Status" appears to be the most general keyword in the top 100 most-cited publications on malnutrition research closely followed by risk. Equally gained prominence among authors is the consequence of malnutrition as seen in the occurrence of "mortality". There is substantial evidence of increased mortality attributed to malnutrition in developing countries. Thus, mortality due to malnutrition calls for global intervention and extensive research to support the most vulnerable global region. Among others, the most frequently explored by top-cited articles were "cardiovascular disease", "obesity", "blood pressure", "supplementation", "quality of life", and "subjective global assessment".

The factors influencing the number of citations are, however, dynamic. For instance, the bibliometric analysis revealed that the journal impact factor was not significantly associated with the number of citations garnered by an article in the top 100 publications on malnutrition. However, MCP have been documented to influence citations (20,21) positively. Also, some authors established that papers with several high citations are usually the work from authors originating from diverse countries and institutions (34). The analysis revealed that of all the factors which were considered in this study, including the journal h-index, years since publication, number of countries involved in the articles, number of authors and institution, was observed to have a positive association with the rate at which other researchers will interact and likely cite a publication. Although the journal names the current bibliometric analysis identified as most productive on the research on malnutrition-related issues, *Lancet*, *Clinical Nutrition*, *American Journal of Clinical Nutrition*, they are predominantly ranked as first quartile (Q1) journals. The number of contributing authors to a publication is correlated with a higher probability of citation. This assertion has been consolidated in other studies (35,36).

On the global platform, the USA has consistently been a pacesetter in innovations. Thus, they represent the country with the most citation on malnutrition research. These trends are the UK, Sweden, Germany, and Australia, ranking high in citations' volume amassed on malnutrition articles. This assertion is consistent with other studies on other research focus such as diets and breast cancer (37) obesity (38), and death due to malnutrition (39). Also, the USA had a high record of international collaboration on malnutrition research.

Similarly, when considering the countries with higher malnutrition publications and their gross domestic product (GDP), the USA, UK, Sweden, and Germany were among the major contributing countries. With the current distribution of malnutrition across the world, the non-representation of Africa and some regions in Asia in the 100 most prominent articles on malnutrition raise several policies and research questions as recent evidence has identified these regions as the most vulnerable to malnutrition (20,26). The low research representation of Africa and other developing countries exposes the policy gap that needs to be addressed. While trying to address this disadvantage encountered by the developing countries, there is a need for global support to provide robust health systems, funding, and high-quality journal platform for developing countries' researchers to thrive (20,40). This study confirms the need for developing countries to upscale their research, funding, and policy frameworks to accelerate the effort to address malnutrition problems plaguing the region.

Numerous studies have explored global malnutrition, and there is evidence of the adverse effect of special groups such as the aging population, children, kidney patients, and hospital patients. For instance, the previous bibliometric that explored the global found that the top themed malnutrition publication was child malnutrition, and there is an interconnection between maternal care and child malnutrition and those with chronic kidney diseases and the aging population (5,20,41). Relative to other studies, keywords such as nutritional status, mortality, developing countries, blood pressure, cardiovascular disease, and growth were the most recurring terms in the current

bibliometrics on top 100 cited articles on malnutrition. The evidence in this study shows that malnutrition has no limitation in its occurrence as it can affect children (42) as stunting and malnourishment intensifying morbidity.

Similarly, with blood in the author's keyword analysis, it further advances that there is interconnection between malnutrition and blood pressure, especially in older adults (43). Other similarly bibliometrics have found that malnutrition research is the most prominent occurring theme in researches focusing on anemia in children (44), cardiovascular diseases (45), and the peculiarity of child malnutrition gain substantial attention in academia and social media (46). Thus the evidence and the magnitude of malnutrition globally calls for comprehensive policy and research intervention that will support the eradication globally. These interventions may include intensifying efforts to increase global food supply and supplement intake among those vulnerable. Research funding and action must be strengthened to highlight risk factors and the geographical dimension of malnutrition occurrence.

Although this study presented a comprehensive bibliometric analysis of the top 100 most-cited publications on global malnutrition research, it is not without a limitation. First, the analysis only adapted publications on the Web of Science databases to assess the trend of malnutrition articles, databases such as, Scopus, Google Scholar, and other biomedical databases were not accessed. Secondly, only articles published in English were included in the analysis; hence, the study is subject to bias. Lastly, despite these limitations, the articles provide an extensive bibliometric analysis that offers a comprehensive overview of research on malnutrition issues.

There has been growth in the number of publications and noticeable collaborations between countries publishing research on malnutrition. Besides, the publications came mainly from the USA, UK, Germany, Australia, and Brazil countries. WHO is the top funding agency for research on malnutrition.

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Supplementary

Table S1 Top 100 cited paper in malnutrition

Rank	Title	TC
1	Black RE, Allen LH, Bhutta ZA, *et al.* Maternal and child undernutrition: global and regional exposures and health consequences. Lancet 2008;371:243-60	2,890
2	Black RE, Victora CG, Walker SP, *et al.* Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 2013;382:427-51	2,851
3	Victora CG, Adair L, Fall C, *et al.* Maternal and child undernutrition: consequences for adult health and human capital. Lancet 2008;371:340-57	1,706
4	Stenvinkel P, Heimbürger O, Paultre F, *et al.* Strong association between malnutrition, inflammation, and atherosclerosis in chronic renal failure. Kidney Int 1999;55:1899-911	1,274
5	Bhutta ZA, Ahmed T, Black RE, *et al.* What works? Interventions for maternal and child undernutrition and survival. Lancet 2008;371:417-40	1,181
6	Winick M, Noble A. Cellular response in rats during malnutrition at various ages. J Nutr 1966;89:300-6	966
7	Correia MI, Waitzberg DL. The impact of malnutrition on morbidity, mortality, length of hospital stay and costs evaluated through a multivariate model analysis. Clin Nutr 2003;22:235-9	937
8	Rubenstein LZ, Harker JO, Salvà A, *et al.* Screening for undernutrition in geriatric practice: developing the short-form mini-nutritional assessment (MNA-SF). J Gerontol A Biol Sci Med Sci 2001;56:M366-72	888
9	McWhirter JP, Pennington CR. Incidence and recognition of malnutrition in hospital. BMJ 1994;308:945-8	872
10	Bistrian BR, Blackburn GL, Vitale J, *et al.* Prevalence of malnutrition in general medical patients. JAMA 1976;235:1567-70	746
11	Norman K, Pichard C, Lochs H, *et al.* Prognostic impact of disease-related malnutrition. Clin Nutr 2008;27:5-15	703
12	Zimmermann MB, Hurrell RF. Nutritional iron deficiency. Lancet 2007;370:511-20	688
13	Waterlow JC. Classification and definition of protein-calorie malnutrition. Br Med J 1972;3:566-9	667
14	Kalantar-Zadeh K, Ikizler TA, Block G, *et al.* Malnutrition-inflammation complex syndrome in dialysis patients: causes and consequences. Am J Kidney Dis 2003;42:864-81	606
15	Smythe PM, Brereton-Stiles GG, Grace HJ, *et al.* Thymolymphatic deficiency and depression of cell-mediated immunity in protein-calorie malnutrition. Lancet 1971;2:939-43	588
16	Cederholm T, Bosaeus I, Barazzoni R, *et al.* Diagnostic criteria for malnutrition - An ESPEN Consensus Statement. Clin Nutr 2015;34:335-40	580
17	Kwong WY, Wild AE, Roberts P, *et al.* Maternal undernutrition during the preimplantation period of rat development causes blastocyst abnormalities and programming of postnatal hypertension. Development 2000;127:4195-202	557
18	Guigoz Y, Lauque S, Vellas BJ. Identifying the elderly at risk for malnutrition. The Mini Nutritional Assessment. Clin Geriatr Med 2002;18:737-57	532
19	Caulfield LE, de Onis M, Blössner M, *et al.* Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. Am J Clin Nutr 2004;80:193-8	504
20	HERBERT V. Experimental nutritional folate deficiency in man. Trans Assoc Am Physicians 1962;75:307-20	503
21	Stratton RJ, Hackston A, Longmore D, *et al.* Malnutrition in hospital outpatients and inpatients: prevalence, concurrent validity and ease of use of the 'malnutrition universal screening tool' ('MUST') for adults. Br J Nutr 2004;92:799-808	499
22	Liu Y, Coresh J, Eustace JA, *et al.* Association between cholesterol level and mortality in dialysis patients: role of inflammation and malnutrition. JAMA 2004;291:451-9	485
23	WILSON PN, OSBOURN DF. Compensatory growth after undernutrition in mammals and birds. Biol Rev Camb Philos Soc 1960;35:324-63	478
24	Kaiser MJ, Bauer JM, Rämsch C, *et al.* Frequency of malnutrition in older adults: a multinational perspective using the mini nutritional assessment. J Am Geriatr Soc 2010;58:1734-8	478
25	Morgane PJ, Austin-LaFrance R, Bronzino J, *et al.* Prenatal malnutrition and development of the brain. Neurosci Biobehav Rev 1993;17:91-128	473
26	Alderman H, Hoddinott J, Kinsey B. Longtermconsequences of early childhood malnutrition. Oxford Economic Papers 2006;58:450-74	464
27	White JV, Guenter P, Jensen G, *et al.* Consensus statement: Academy of Nutrition and Dietetics and American Society for Parenteral and Enteral Nutrition: characteristics recommended for the identification and documentation of adult malnutrition (undernutrition). JPEN J Parenter Enteral Nutr 2012;36:275-83	447
28	Embleton NE, Pang N, Cooke RJ. Postnatal malnutrition and growth retardation: an inevitable consequence of current recommendations in preterm infants? Pediatrics 2001;107:270-3	444
29	Mullen JL, Gertner MH, Buzby GP, *et al.* Implications of malnutrition in the surgical patient. Arch Surg 1979;114:121-5	438
30	Hill GL, Blackett RL, Pickford I, *et al.* Malnutrition in surgical patients. An unrecognised problem. Lancet 1977;1:689-92	437
31	Qureshi AR, Alvestrand A, Danielsson A, *et al.* Factors predicting malnutrition in hemodialysis patients: a cross-sectional study. Kidney Int 1998;53:773-82	437
32	Wagstaff A, van Doorslaer E, Watanabe N. On decomposing the causes of healthsectorinequalities with an application to malnutritioninequalities in Vietnam. Journal of Econometrics 2003;112: 207-23	435
33	Hashimoto T, Perlot T, Rehman A, *et al.* ACE2 links amino acid malnutrition to microbial ecology and intestinal inflammation. Nature 2012;487:477-81	431
34	Müller O, Krawinkel M. Malnutrition and health in developing countries. CMAJ 2005;173:279-86.	425
35	Lim SL, Ong KC, Chan YH, *et al.* Malnutrition and its impact on cost of hospitalization, length of stay, readmission and 3-year mortality. Clin Nutr 2012;31:345-50	410
36	Pelletier DL, Frongillo EA Jr, Schroeder DG, *et al.* The effects of malnutrition on child mortality in developing countries. Bull World Health Organ 1995;73:443-8	408
37	Pirlich M, Schütz T, Norman K, *et al.* The German hospital malnutrition study. Clin Nutr 2006;25:563-72	407
38	Schaible UE, Kaufmann SH. Malnutrition and infection: complex mechanisms and global impacts. PLoS Med 2007;4:e115	407
39	Ferguson M, Capra S, Bauer J, *et al.* Development of a valid and reliable malnutrition screening tool for adult acute hospital patients. Nutrition 1999;15:458-64	399
40	Milne AC, Potter J, Vivanti A, *et al.* Protein and energy supplementation in elderly people at risk from malnutrition. Cochrane Database Syst Rev 2009;(2):CD003288	399
41	Waitzberg DL, Caiaffa WT, Correia MI. Hospital malnutrition: the Brazilian national survey (IBRANUTRI): a study of 4000 patients. Nutrition 2001;17:573-80	393
42	Deitch EA, Winterton J, Li M, *et al.* The gut as a portal of entry for bacteremia. Role of protein malnutrition. Ann Surg 1987;205:681-92	380
43	Agrawal Y, Carey JP, Della Santina CC, *et al.* Disorders of balance and vestibular function in US adults: data from the National Health and Nutrition Examination Survey, 2001-2004. Arch Intern Med 2009;169:938-44	378
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45	Chen LC, Chowdhury A, Huffman SL. Anthropometric assessment of energy-protein malnutrition and subsequent risk of mortality among preschool aged children. Am J Clin Nutr 1980;33:1836-45	363
46	Honda H, Qureshi AR, Heimbürger O, *et al.* Serum albumin, C-reactive protein, interleukin 6, and fetuin a as predictors of malnutrition, cardiovascular disease, and mortality in patients with ESRD. Am J Kidney Dis 2006;47:139-48	363
47	Swinburn BA, Kraak VI, Allender S, *et al.* The Global Syndemic of Obesity, Undernutrition, and Climate Change: The Lancet Commission report. Lancet 2019;393:791-846	358
48	Faggioni R, Feingold KR, Grunfeld C. Leptin regulation of the immune response and the immunodeficiency of malnutrition. FASEB J 2001;15:2565-71	356
49	Barker LA, Gout BS, Crowe TC. Hospital malnutrition: prevalence, identification and impact on patients and the healthcare system. Int J Environ Res Public Health 2011;8:514-27	355
50	Weinsier RL, Hunker EM, Krumdieck CL, *et al.* Hospital malnutrition. A prospective evaluation of general medical patients during the course of hospitalization. Am J Clin Nutr 1979;32:418-26	345
51	Chandra RK. Immunocompetence in undernutrition. J Pediatr 1972;81:1194-200	340
52	Bouis HE, Hotz C, McClafferty B, *et al.* Biofortification: a new tool to reduce micronutrient malnutrition. Food Nutr Bull 2011;32:S31-40	338
53	Qureshi AR, Alvestrand A, Divino-Filho JC, *et al.* Inflammation, malnutrition, and cardiac disease as predictors of mortality in hemodialysis patients. J Am Soc Nephrol 2002;13 Suppl 1:S28-36	335
54	Ingenbleek Y, Van Den Schrieck HG, De Nayer P, *et al.* Albumin, transferrin and the thyroxine-binding prealbumin/retinol-binding protein (TBPA-RBP) complex in assessment of malnutrition. Clin Chim Acta 1975;63:61-7	332
55	Cegielski JP, McMurray DN. The relationship between malnutrition and tuberculosis: evidence from studies in humans and experimental animals. Int J Tuberc Lung Dis 2004;8:286-98	330
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57	Sullivan DH, Sun S, Walls RC. Protein-energy undernutrition among elderly hospitalized patients: a prospective study. JAMA 1999;281:2013-9	325
58	Morgane PJ, Miller M, Kemper T, *et al.* The effects of protein malnutrition on the developing central nervous system in the rat. Neuroscience & Biobehavioral Reviews 1978;2:137-230	324
59	Stephenson LS, Latham MC, Ottesen EA. Malnutrition and parasitic helminth infections. Parasitology 2000;121 Suppl:S23-38	321
60	Curtis CR, Erb HN, Sniffen CJ, *et al.* Path analysis of dry period nutrition, postpartum metabolic and reproductive disorders, and mastitis in Holstein cows. J Dairy Sci 1985;68:2347-60	315
61	Yura S, Itoh H, Sagawa N, *et al.* Role of premature leptin surge in obesity resulting from intrauterine undernutrition. Cell Metab 2005;1:371-8	311
62	Mendenhall CL, Anderson S, Weesner RE, *et al.* Protein-calorie malnutrition associated with alcoholic hepatitis. Veterans Administration Cooperative Study Group on Alcoholic Hepatitis. Am J Med 1984;76:211-22	305
63	Graham RD, Welch RM, Bouis H, *et al.* Addressingmicronutrientmalnutrition through enhancing the nutritionalquality of staplefoods: Principles, perspectives and knowledgegaps. Advances in Agronomy 2001;70:77-142	303
64	Stanner SA, Bulmer K, Andrès C, *et al.* Does malnutrition in utero determine diabetes and coronary heart disease in adulthood? Results from the Leningrad siege study, a cross sectional study. BMJ 1997;315:1342-8	300
65	White JV, Guenter P, Jensen G, *et al.* Consensus statement of the Academy of Nutrition and Dietetics/American Society for Parenteral and Enteral Nutrition: characteristics recommended for the identification and documentation of adult malnutrition (undernutrition). J Acad Nutr Diet 2012;112:730-8	298
66	Widdowson EM, Mccance RA. The effect of finite periods of undernutrition at different ages on the composition and subsequent development of the rat. Proc R Soc Lond B Biol Sci 1963;158:329-42	297
67	Winick M. Malnutrition and brain development. J Pediatr 1969;74:667-79	293
68	Holzel A, Schwarz V, Sutcliffe KW. Defective lactose absorption causing malnutrition in infancy. Lancet 1959;1:1126-8	292
69	Lesage J, Blondeau B, Grino M, *et al.* Maternal undernutrition during late gestation induces fetal overexposure to glucocorticoids and intrauterine growth retardation, and disturbs the hypothalamo-pituitary adrenal axis in the newborn rat. Endocrinology 2001;142:1692-702	291
70	Shetty PS, Watrasiewicz KE, Jung RT, *et al.* Rapid-turnover transport proteins: an index of subclinical protein-energy malnutrition. Lancet 1979;2:230-2	283
71	Dávalos A, Ricart W, Gonzalez-Huix F, *et al.* Effect of malnutrition after acute stroke on clinical outcome. Stroke 1996;27:1028-32	280
72	Giner M, Laviano A, Meguid MM, *et al.* In 1995 a correlation between malnutrition and poor outcome in critically ill patients still exists. Nutrition 1996;12:23-9	276
73	Guerrant RL, Oriá RB, Moore SR, *et al.* Malnutrition as an enteric infectious disease with long-term effects on child development. Nutr Rev 2008;66:487-505	275
74	Woodall SM, Johnston BM, Breier BH, *et al.* Chronic maternal undernutrition in the rat leads to delayed postnatal growth and elevated blood pressure of offspring. Pediatr Res 1996;40:438-43	274
75	Rice AL, Sacco L, Hyder A, *et al.* Malnutrition as an underlying cause of childhood deaths associated with infectious diseases in developing countries. Bull World Health Organ 2000;78:1207-21	274
76	Pelletier DL, Frongillo EA Jr, Habicht JP. Epidemiologic evidence for a potentiating effect of malnutrition on child mortality. Am J Public Health 1993;83:1130-3	272
77	de Onis M, Frongillo EA, Blössner M. Is malnutrition declining? An analysis of changes in levels of child malnutrition since 1980. Bull World Health Organ 2000;78:1222-33	270
78	Naber TH, Schermer T, de Bree A, *et al.* Prevalence of malnutrition in nonsurgical hospitalized patients and its association with disease complications. Am J Clin Nutr 1997;66:1232-9	268
79	Edington J, Boorman J, Durrant ER, *et al.* Prevalence of malnutrition on admission to four hospitals in England. The Malnutrition Prevalence Group. Clin Nutr 2000;19:191-5	266
80	Charbonneau MR, O'Donnell D, Blanton LV, *et al.* Sialylated Milk Oligosaccharides Promote Microbiota-Dependent Growth in Models of Infant Undernutrition. Cell 2016;164:859-71	266
81	de Onís M, Monteiro C, Akré J, *et al.* The worldwide magnitude of protein-energy malnutrition: an overview from the WHO Global Database on Child Growth. Bull World Health Organ 1993;71:703-12	261
82	Winick M, Rosso P. The effect of severe early malnutrition on cellular growth of human brain. Pediatr Res 1969;3:181-4	259
83	Hintz RL, Suskind R, Amatayakul K, *et al.* Plasma somatomedin and growth hormone values in children with protein-calorie malnutrition. J Pediatr 1978;92:153-6	259
84	Mulinos MG, Pomerantz L. Pseudo-Hypophysectomy: A Condition Resembling Hypophysectomy Produced by Malnutrition, Two Figures. Journal of Nutrition 1940;19:493-504	258
85	Kim SH, Choi YM, Lee MG. Pharmacokinetics and pharmacodynamics of furosemide in protein-calorie malnutrition. J Pharmacokinet Biopharm 1993;21:1-17	255
86	Clasen T, Boisson S, Routray P, *et al.* Effectiveness of a rural sanitation programme on diarrhoea, soil-transmitted helminth infection, and child malnutrition in Odisha, India: a cluster-randomised trial. Lancet Glob Health 2014;2:e645-53	255
87	Lopes J, Russell DM, Whitwell J, *et al.* Skeletal muscle function in malnutrition. Am J Clin Nutr 1982;36:602-10	254
88	Kruizenga HM, Seidell JC, de Vet HC, *et al.* Development and validation of a hospital screening tool for malnutrition: the short nutritional assessment questionnaire (SNAQ). Clin Nutr 2005;24:75-82	254
89	Stoch MB, Smythe PM. Does Undernutrition During Infancy Inhibit Brain Growth and Subsequent Intellectual Development? Arch Dis Child 1963;38:546-52	253
90	Morgane PJ, Mokler DJ, Galler JR. Effects of prenatal protein malnutrition on the hippocampal formation. Neurosci Biobehav Rev 2002;26:471-83	250
91	Cederholm T, Jensen GL, Correia MITD, *et al.* GLIM criteria for the diagnosis of malnutrition - A consensus report from the global clinical nutrition community. Clin Nutr 2019;38:1-9	250
92	Ingenbleek Y, De Visscher M, De Nayer P. Measurement of prealbumin as index of protein-calorie malnutrition. Lancet 1972;2:106-9	249
93	de Onis M, Blössner M. The World Health Organization Global Database on Child Growth and Malnutrition: methodology and applications. Int J Epidemiol 2003;32:518-26	246
94	Jensen GL, Mirtallo J, Compher C, *et al.* Adult starvation and disease-related malnutrition: a proposal for etiology-based diagnosis in the clinical practice setting from the International Consensus Guideline Committee. JPEN J Parenter Enteral Nutr 2010;34:156-9	245
95	Mayer JE, Pfeiffer WH, Beyer P. Biofortified crops to alleviate micronutrient malnutrition. Curr Opin Plant Biol 2008;11:166-70	242
96	Hakim RM, Levin N. Malnutrition in hemodialysis patients. Am J Kidney Dis 1993;21:125-37	240
97	Recker RR, Hinders S, Davies KM, *et al.* Correcting calcium nutritional deficiency prevents spine fractures in elderly women. J Bone Miner Res 1996;11:1961-6	238
98	Alvares-da-Silva MR, Reverbel da Silveira T. Comparison between handgrip strength, subjective global assessment, and prognostic nutritional index in assessing malnutrition and predicting clinical outcome in cirrhotic outpatients. Nutrition 2005;21:113-7	238
99	Wang AY, Woo J, Lam CW, *et al.* Associations of serum fetuin-A with malnutrition, inflammation, atherosclerosis and valvular calcification syndrome and outcome in peritoneal dialysis patients. Nephrol Dial Transplant 2005;20:1676-85	236
100	Bryce J, Coitinho D, Darnton-Hill I, *et al.* Maternal and child undernutrition: effective action at national level. Lancet 2008;371:510-26	235

TC, total citations.

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Table S2 Authors who contributed to at least 3 or more articles with h-index of the 100 most-cited malnutrition papers

SCR	Author (n=548)	Author's affiliations[a]	h-index	g-index	Authorship position			NP	TC
					1st	2nd	3rd or last		
1	Black RE	Johns Hopkins University, School of Public Health, Baltimore, USA.	5	5	2	2	1	5	7,700
2	De Onis M	Department of Nutrition for Health and Development, WHO, Geneva, Switzerland	5	5	2	1	2	5	6,761
9	Bhutta ZA	Aga Khan University, Karachi, Pakistan	3	3	1	0	2	3	6,922
10	Blossner M	Department of Nutrition for Health and Development, World Health Organization, Geneva, Switzerland.	3	3	1	0	2	3	1,020
11	Cederholm T	Departments of Geriatric Medicine, Uppsala University, Sweden	3	3	2	0	1	3	1,308
12	Correia MITD	Universidade Federal de Minas Gerais, Belo Horizonte, Brazil.	3	3	1	0	2	3	1,580
13	Ezzati M	John Hopkins Bloomberg School of Public Health, Baltimore, MD, USA.	3	3	0	0	3	3	6,099
14	Frongillo EA	Division of Nutritional Sciences, Cornell University, Ithaca,	3	3	0	2	1	3	950
15	Guigoz Y	Nestlé Product and Technology Centre, Switzerland.	3	3	1	0	2	3	1,898
16	Heimburger O	Department of Medicine, Columbia University, New York, New York, USA	3	3	0	1	2	3	1,972
17	Lindholm B	Department of Clinical Science, Karolinska Institute, Huddinge University Hospital, Stockholm, Sweden	3	3	0	0	3	3	1,135
3	Malone A	Mt. Carmel West Hospital, Columbus, Ohio	3	3	0	0	3	3	995
4	Morgane PJ	Worcester Foundation for Experimental Biology, Shrewsbury, MA.	3	3	3	0	0	3	1,047
5	Nyulasi I	Department of Nutrition and Dietetics and Department of Medicine, Monash University Central Clinical School, Prahran, Australia	3	3	0	0	3	3	1,075
6	Pirlich M	Medizinische Klinik mit Schwerpunkt Gastroenterologie, Hepatologie und Endokrinologie, Charité–Universitätsmedizin Berlin, Berlin	3	3	1	0	2	3	1,360
7	Qureshi AR	Department of Clinical Science, Karolinska Institute, Huddinge University Hospital, Stockholm, Sweden	3	3	2	1	0	3	1,135
8	Winick M	Department of Pediatrics, Cornell University Medical College, New York	3	3	3	0	0	3	1,518

[a], the frequency distribution of affiliations (of all co-authors for each paper). SCR, standard competition ranking; NP, number of articles; TC, total number of citations reported per documents.

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