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Systematic Review

Global Evolution of Obesity Research in Children and Youths: Setting Priorities for Interventions and Policies

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Keywords
Scientometrics · Child obesity · Global evolution · Mapping

Abstract
Background: Childhood obesity has become a major global epidemic that causes substantial social and health burdens worldwide. The effectiveness of childhood obesity control and prevention depends largely on understanding the issue, including its current development and associated factors in a contextualized perspective. ***Objectives:*** Our study aimed to gauge this kind of understanding. ***Methods:*** We systematically searched the Web of Science database for studies concerning child obesity published up to 2017 and analyzed the volume of publications, growth rates, impact scores, collaborations, authors, affiliations, and journals. A total of 57,444 research papers were included. ***Results:*** The three subject categories with the highest number of papers (over 3,000) were (1) nutrition and dietetics, (2) pediatrics, and (3) public, environmental, and occupational health. We found a dramatic increase in the amount of scientific literature on childhood obesity in the past one or two decades, led by scholars from the USA – ranking at the top regarding the total number of papers (23,965 papers; 30.8%) and total number of citations (859,793 citations) – and multiple Western countries where the obesity epidemic is prevalent. ***Conclusions:*** The findings highlight the need for improving international and local research capacities and collaboration to accelerate knowledge production and translation into contextualized and effective childhood obesity prevention.

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Introduction

Childhood obesity has become a major global epidemic that imposes a substantial social and health burden worldwide [1, 2]. An estimated 4.0 million deaths and 120 million disability-adjusted life years (DALYs) in 2015 were attributable to an excess body mass index (BMI) globally [3]. Obesity in childhood is a special concern, given its life course impact by causing the development of multiple chronic conditions. Specifically, children who are overweight are more likely to become obese at a later age [4, 5], have a deteriorated quality of life and significantly higher health care costs, and live less long [6, 7]. Previous studies have documented associations of childhood obesity with the development of musculoskeletal disorders, hypertension, cardiovascular disease, and diabetes [5, 8]. Furthermore, overweight children have poorer mental health as a result of having low self-esteem, body image disturbance, and depression [5, 9].

The childhood obesity epidemic has been expanding in both developed and developing countries. According to the World Health Organization (WHO), 381 million children under 20 years were overweight or obese in 2016 [2, 5, 10]. Over the past four decades, the prevalence of excess weight in both male and female adolescents has been substantially increasing (from 4 to over 18%) [10]. Curbing this continuing epidemic requires strong global political commitment, involvement of stakeholders, and synergetic efforts from nations and communities in effectively delivering preventive and management strategies. The United Nations have acted to advance the implementation of global commitment by launching the WHO Global Strategy on Diet, Physical Activity and Health [11, 12]. In 2016, a report by the Commission on Ending Childhood Obesity suggested six recommendations for obesity control at global, regional and local levels; it was presented at the World Health Assembly in 2017 [13].

Implementing these recommendations requires enormous amounts of evidence, but the availability and applicability of evidence are heterogeneous across settings. Many developing countries, where there is a double burden of malnutrition, are not sufficiently capable of producing timely evidence to inform policy development [14, 15]. In addition, the translation of international research findings into a specific setting may be confined by many sociocultural and structural barriers and may face challenges in maintaining a long-term impact of interventions [2, 10, 16]. Thus, exploring any evidence gaps and institutions with sufficient networks and capacities is vital to ensure the effectiveness and substantiality of further interventions in the field of childhood obesity.

One method that would be appropriate for measuring these gaps is scientometric analysis [17]. This method objectively measures the international and national interest in specific research topics through examining tendencies in published articles over time and networks of research collaborations in literature databases [18, 19]. By offering such insights, this approach fosters effective government investments in research [20]. To date, several scientometric studies on obesity have been conducted, but they only focused on people in the Middle East or India [21, 22]. None of them provided evidence about global research on childhood obesity. Therefore, we aimed to analyze the global growth of research production and patterns of research areas in the field of childhood obesity.

Methods

Bibliographic Database

The Web of Science database (WoS) was used for searching, which is the oldest database covering citation and bibliographic data since 1900 [23]. WoS provides more comprehensive

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data (such as author information, journal, and publication year) that allow for in-depth analysis than other databases like Scopus and MEDLINE. Articles in WoS are tagged according to document type, such as review articles or original articles, following a standardized structure, which is vital for a literature analysis [24].

In this study, we also collected DALYs (rate) and BMI data from the Global Burden of Diseases website (http://ghdx.healthdata.org/gbd-results-tool). We extracted only data from 2016 regardless of sex, age group, and location, due to inconsistencies in year ranges.

Search Strategy

The WHO's definition of childhood obesity and other previous studies were adopted to build the search strategy [5, 9, 25–27], focusing on (1) child and (2) obesity. The search strategy was as follows and as displayed in online supplementary Table S1 (for all online suppl. material, see www.karger.com/doi/10.1159/000497121):

1. Child* OR Pediatric* OR Paediatric* OR Infant* OR newborn* OR bab* OR Toddler* OR pre-adolescen* OR preadolescen* OR Adolescen* OR Youth* OR Youngster* OR Teen* OR Teenager* OR teenage OR preschooler* OR pre-schooler* OR pre-school* OR preschool* OR "Pre-school child*" OR "school-aged child*" OR schoolchild* OR "school age*" OR Schoolage* OR "nursery school*" OR kindergar* OR "primary school*" OR "secondary school*" OR "grade school*" OR "elementary school*" OR "high school*" OR highschool*
2. Overweight OR "Over weight" OR Preobes* OR Pre-obes* OR Obes* OR overnutrition OR "excessive fat accumulation" OR "fat levels" OR "excess body fat" OR "weight disorder" OR "High body mass index"

Only research articles and review articles were included in our study, while others were excluded. Papers published from January 1, 2018, onward were excluded due to the incomplete bibliometric data for that year. Documents having anonymous authors and papers written in languages other than English were also removed.

Data Extraction

The exported data included: (1) title and abstract; (2) authors' names and their affiliations; (3) citations for each paper; (4) institutional affiliations; (5) year of publication; (6) author keywords; and (7) research area.

Data Analysis

The data included information on general characteristics (total publications, publication year, number of authors, and main category); the most prolific authors (more than 100 papers); the countries and institutions/organizations with the highest total number of publications; journal details and highly impactful papers (times cited: more than 1,300 times); and keywords (most common keywords and co-occurrence of keywords). Then, we synthesized the data on the number of publications and DALYs in order to show whether the research productivity in each country aligned with the disease burden regarding obesity [3].

As there were differences in countries' names between the databases (e.g., "USA" in WoS and "United States" in the Global Burden of Disease Study data), one of the authors (G.H.H.) checked for inconsistencies, while another one (L.H.N.) verified the data. Any discrepancies between the two researchers were resolved via discussion.

Overviews of the collaborations from the most productive countries as well as the most cited papers were created using the VOSviewer software (http://www.vosviewer.com/). A visualization map represented collaborations and contributions from 110 countries using a threshold of 10 or more publications. We also used this software to generate co-occurrence networks of keywords by using keyword frequency (218 keywords with a minimum of 100

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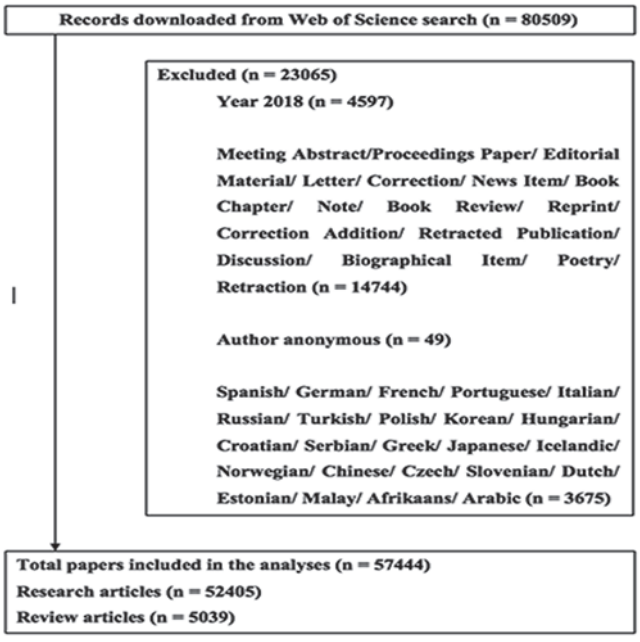

Fig. 1. Selection of papers.

appearances). The thresholds were chosen based on our experiments with VOSviewer to achieve a presentation most appropriately reflecting a global overview of collaborations. The 2016 population data were collected from the World Bank website (https://data.worldbank.org/indicator/SP.POP.TOTL) to calculate the number of publications per million inhabitants. For Wales, Scotland, and Northern Ireland, we used the Office for National Statistics Great Britain to obtain the population data (https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates).

Results

Numbers of Papers and Publication Trends

The study selection process is shown in Figure 1. There were 80,509 studies published between 1920 and 2017. After removing 23,065 studies that did not match the eligibility criteria, a total of 57,444 research papers were included in the analysis, consisting of 52,405 research articles and 5,039 review articles.

Figure 2 illustrates the general trend of the search results. Since 1970, the volume of research articles has increased dramatically every 10 years. Noticeably, approximately 63% of all publications were published in the period from 2011 to 2017. Regarding the location of the first author, the greatest number of publications in childhood obesity research came from the USA (n = 21,045; 36.6%), followed by England (n = 3,168; 5.5%). Papers with 4–6 authors accounted for the largest proportion (41.9%) (Fig. 3; online suppl. Table S1).

Journal Diversity and Author Collaborations

The majority of articles were classified as having 1 (64.3%) or 2 (28.7%) journal subject categories (online suppl. Table S1). The most common subject categories are displayed in Figure 4. There were 6 subject categories with regard to childhood obesity being covered by more than 3,000 papers per category, including: nutrition and dietetics; pediatrics; public,

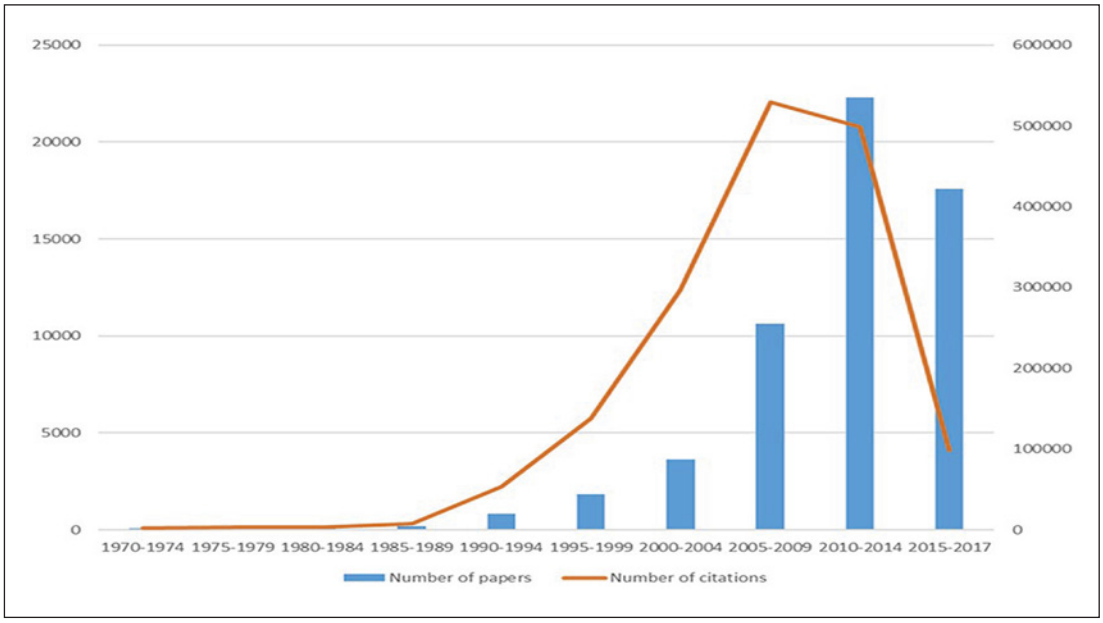

Fig. 2. Numbers of papers and citations in different time periods.

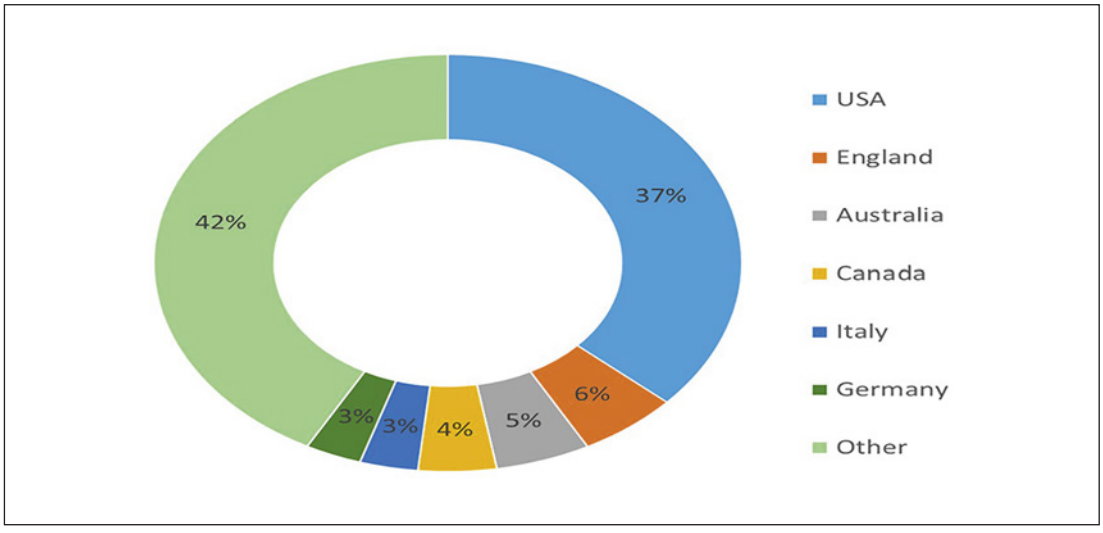

Fig. 3. Countries of origin of the first authors.

environmental, and occupational health; endocrinology and metabolism; general and internal medicine; and psychology. The *International Journal of Obesity* had the highest number of papers in the field of nutrition and dietetics (n = 1,445) and endocrinology and metabolism (n = 1,445 papers) (online suppl. Table S2).

Table 1 shows that the collaboration index (the average number of authors per article) was generally increasing during the period, with the highest index (6.42) seen in 2017. Most of the first authors were from North American countries (USA and Canada) and Europe (England, Spain, Greece, Germany, Belgium, Hungary, Denmark, The Netherlands, and Italy).

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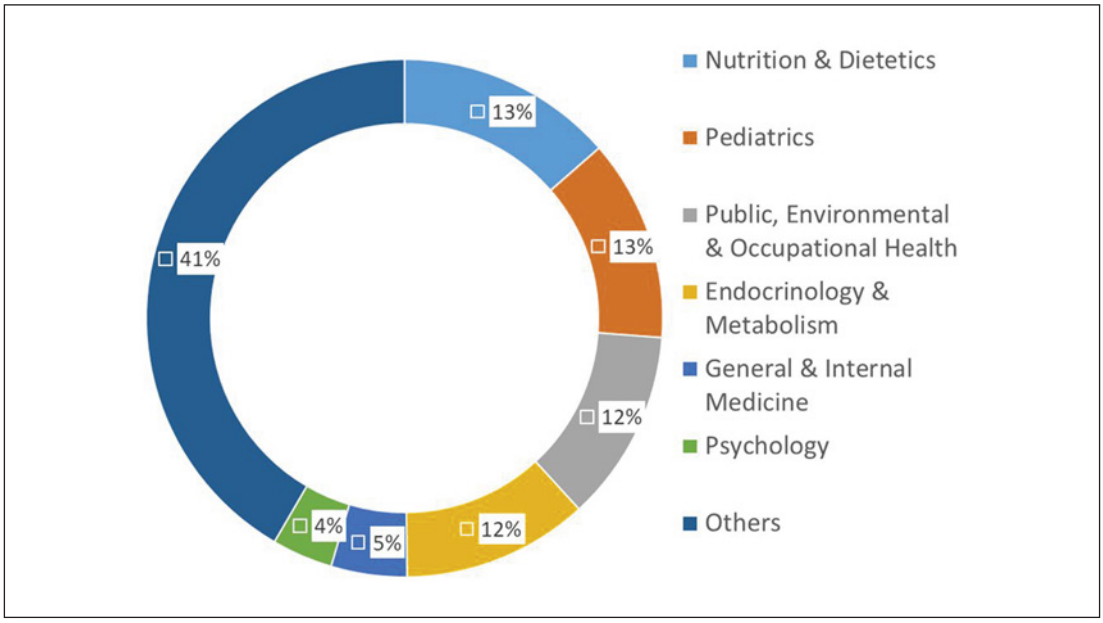

Fig. 4. The most common research areas.

Table 1. Collaboration index of researchers in the field of child obesity

Year	Collaboration index
2000	4.92
2001	4.53
2002	4.57
2003	4.94
2004	4.80
2005	4.79
2006	4.89
2007	5.01
2008	5.02
2009	5.28
2010	5.11
2011	5.25
2012	5.40
2013	5.56
2014	5.69
2015	5.88
2016	6.25
2017	6.42

The country with the highest number of most productive authors was the USA with 11 authors (online suppl. Table S3). The total volume of papers published by the most productive authors varied from 108 to 285, and the total number of citations ranged from 3,701 to 16,076. L.A. Moreno from Spain was the author who had published the highest total number of papers (n = 285) and the highest number of papers in collaboration (n = 284). However, S.R. Daniels from the University of Cincinnati College of Medicine, Cincinnati, OH, USA, led regarding the total number of citations (n = 16,076), while G.S. Berenson from the Tulane School of Public Health and Tropical Medicine, New Orleans, LA, USA, had the highest number of citations per paper (n = 118.57) (online suppl. Table S3).

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Country Collaborations

Table 2 shows that the 5 countries ranking at the top in productivity were from North America (the USA with 23,965 papers and Canada with 3,441 papers), East Asia and Pacific (Australia with 3,939 papers), and Europe (England with 5,150 papers and Germany with 2,510 papers); all of them are high-income countries. The USA led and ranked first in the total number of papers (n = 23,965; 30.8%), total number of citations (n = 859,793), and distinct countries of collaboration (n = 175). The main collaborations of authors from the USA were with authors from England (n = 868 papers). England ranked second in the total number of papers (5,150 papers) and was the primary partner of the USA, Australia, and European countries (Denmark, Finland, and Scotland). Among Asian countries, the People's Republic of China had the highest research productivity (a total of 2,273 papers), followed by Japan (a total of 1,076 papers) and South Korea (a total of 883 papers). The number of papers per million inhabitants was lowest in India with 0.9 papers per million inhabitants, whereas Denmark ranked first with 182.5 papers per million inhabitants (Table 2).

Figure 5 displays a visual map of the research contributions of the top 110 countries with a minimum of 10 papers. The USA accounted for the largest proportion of contributors and mainly collaborated with England, Canada, Australia, and the People's Republic of China. Several countries in Western Europe, such as Germany, Spain, Belgium, Italy, and France, were in the same cluster of collaboration. Clusters were also seen among the Netherlands, Norway, and Switzerland, as well as East and South Asian countries such as Singapore, Thailand, Taiwan, the People's Republic of China, Japan, and India (Fig. 5).

The USA had the largest total number of papers, and the DALYs (rate) attributable to a high BMI (online suppl. Table S4) were also high in general as well as for both males and females (44.2 and 55.3, respectively). Although Brazil ranked 6th, Turkey ranked 14th, and Iran ranked 15th regarding the total number of papers, the DALYs in these countries were significantly higher than in other countries among the top 20. South Korea had a high percentage of overweight/obese children in 2016 compared to other top 20 countries, but its DALYs were low. Several Western European countries such as Germany, Spain, Belgium, Italy, and France, which were in the same cluster of collaboration, had a high prevalence of overweight/obesity among both genders in 2016 (online suppl. Table S4).

Keyword Analysis

Figure 6 illustrates the co-occurrence of papers' keywords. Overall, there were 39,397 keywords, of which 218 keywords were used 100 times or more. We assigned those to four groups:

1. Obesity classification: information about BMI, adiposity, weight gain, and birth weight
2. Consequences of childhood obesity: metabolic syndrome, hypertension, insulin resistance, and blood pressure
3. Effects: depression, body image, and weight loss as the effects of obesity on adolescents
4. Interventions related to childhood obesity: health promotion, physical activity, diet, and parent support

The relationship between mental health (depression or stress) and childhood obesity was not receiving suitable attention. Depression and stress appeared 361 times (0.92%) and 136 times (0.34%), respectively. Although obesity is not a mental health disorder, its impact on the psychological health of those living with obesity, especially children or adolescents, should be considered [28]. Meanwhile, the "intervention" keywords showed that the most common topics of interventions were physical activity, education, food intake, and diet with the support of parents, and that the main subjects were students and youths.

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Table 2. Most prolific countries and the collaborations

Region	Rank	Countries	Total papers, *n*	%*N*	Papers per million inhabitants, *n*	Total citations, *n*	Citations per paper, *n*	Intra-country collaborations, *n*	%	Inter-country collaborations, *n*	%	Distinct countries of collaboration, *n*	Main collaborator (collaborations, *n*)	Country classification
North America	1	USA	23,965	30.8	73.6	859,793	35.9	22,220	92.7	1,745	7.3	175	England (868)	High income
	4	Canada	3,441	4.4	93.7	102,810	29.9	3,253	94.5	188	5.5	155	USA (820)	High income
Middle East and North Africa	22	Iran	794	1	9.8	24,684	31.1	769	96.9	25	3.2	141	USA (58)	Upper middle income
	23	Israel	785	1	90.1	35,977	45.8	753	95.9	32	4.1	142	USA (307)	High income
Latin America and the Caribbean	11	Brazil	1,828	2.4	8.7	31,962	17.5	1,796	98.3	32	1.8	146	USA (270)	Upper middle income
	21	Mexico	804	1	6.2	23,448	29.2	785	97.6	19	2.4	141	USA (364)	Upper middle income
South Asia	13	India	1,239	1.6	0.9	33,945	27.4	1,172	94.6	67	5.4	146	USA (470)	Lower middle income
Europe and Central Asia	2	England	5,150	6.6	92.6	248,234	48.2	4,728	91.8	422	8.2	162	USA (868)	High income
	5	Germany	2,510	3.2	30.4	85,234	34	2,353	93.8	157	6.3	151	USA (336)	High income
	6	Italy	2,429	3.1	40.1	73,407	30.2	2,267	93.3	162	6.7	150	France (451)	High income
	8	France	1,962	2.5	29.2	66,838	34.1	1,891	96.4	71	3.6	151	Italy (451)	High income
	9	The Netherlands	1,878	2.4	109.6	62,148	33.1	1,828	97.3	50	2.7	152	USA (312)	High income
	10	Spain	1,857	2.4	39.9	49,577	26.7	1,799	96.9	58	3.1	149	Belgium (350)	High income
	12	Sweden	1,686	2.2	167.5	63,699	37.8	1,604	95.1	82	4.9	148	Spain (301)	High income
	14	Turkey	1,071	1.4	13.3	14,176	13.2	1,010	94.3	61	5.7	143	USA (48)	Upper middle income
	16	Denmark	1,053	1.4	182.5	32,503	30.9	1,012	96.1	41	3.9	146	England (198)	High income
	17	Belgium	1,011	1.3	88.9	36,150	35.8	965	95.5	46	4.6	143	Spain (350)	High income
	19	Greece	871	1.1	80.9	30,057	34.5	830	95.3	41	4.7	136	Spain (186)	High income
	20	Finland	860	1.1	156	42,553	49.5	819	95.2	41	4.8	143	England (221)	High income
	25	Switzerland	752	1	88.8	40,314	53.6	706	93.9	46	6.1	145	USA (164)	High income
	26	Norway	749	1	141.8	29,679	39.6	732	97.7	17	2.3	143	USA (152)	High income
	27	Scotland	740	1	136.9	40,724	55	696	94.1	44	6.0	129	England (326)	High income
	28	Poland	717	0.9	18.9	9,893	13.8	682	95.1	35	4.9	136	Germany (95)	High income
	29	Portugal	562	0.7	54.6	11,106	19.8	549	97.7	13	2.3	145	USA (135)	High income
	30	Ireland	513	0.7	106.6	14,708	28.7	491	95.7	22	4.3	136	England (117)	High income
East Asia and Pacific	3	Australia	3,939	5.1	160.1	121,641	30.9	3,732	94.7	207	5.3	158	England (514)	High income
	7	China	2,273	2.9	1.6	49,821	21.9	2,215	97.5	58	2.6	148	USA (589)	Upper middle income
	15	Japan	1,067	1.4	8.4	31,275	29.3	950	89.0	117	11.0	149	USA (121)	High income
	18	South Korea	883	1.1	17.2	19,624	22.2	0	0.0	883	100.0	146	USA (218)	High income
	24	New Zealand	764	1	159.4	31,278	40.9	0	0.0	764	100.0	140	Australia (198)	High income

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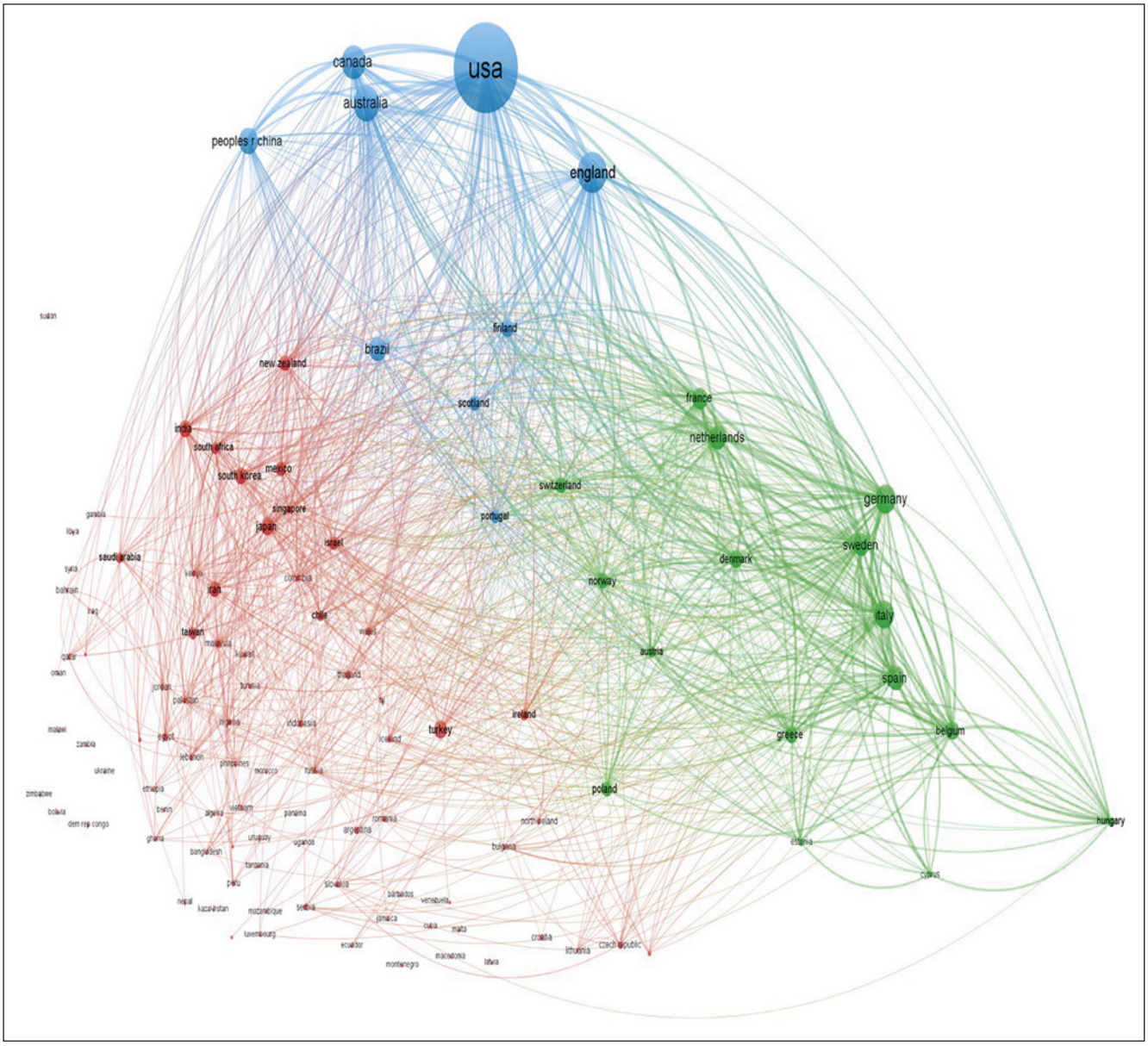

Fig. 5. Global networks of the most prolific countries.

Discussion

This review summarized the global research development in the field of childhood obesity. We found a dramatic increase in the amount of scientific literature on childhood obesity in the past two decades, led by scholars from the USA and Western countries, where the obesity epidemic is prevalent. The clusters of collaboration between countries in childhood obesity research were mainly based on cultural similarity and geographic proximity. There was a disproportionality between the number of publications and the burden of childhood obesity in several countries, showing potential knowledge gaps regarding interventions. Furthermore, the major part of the research focused on assessing excess weight status and

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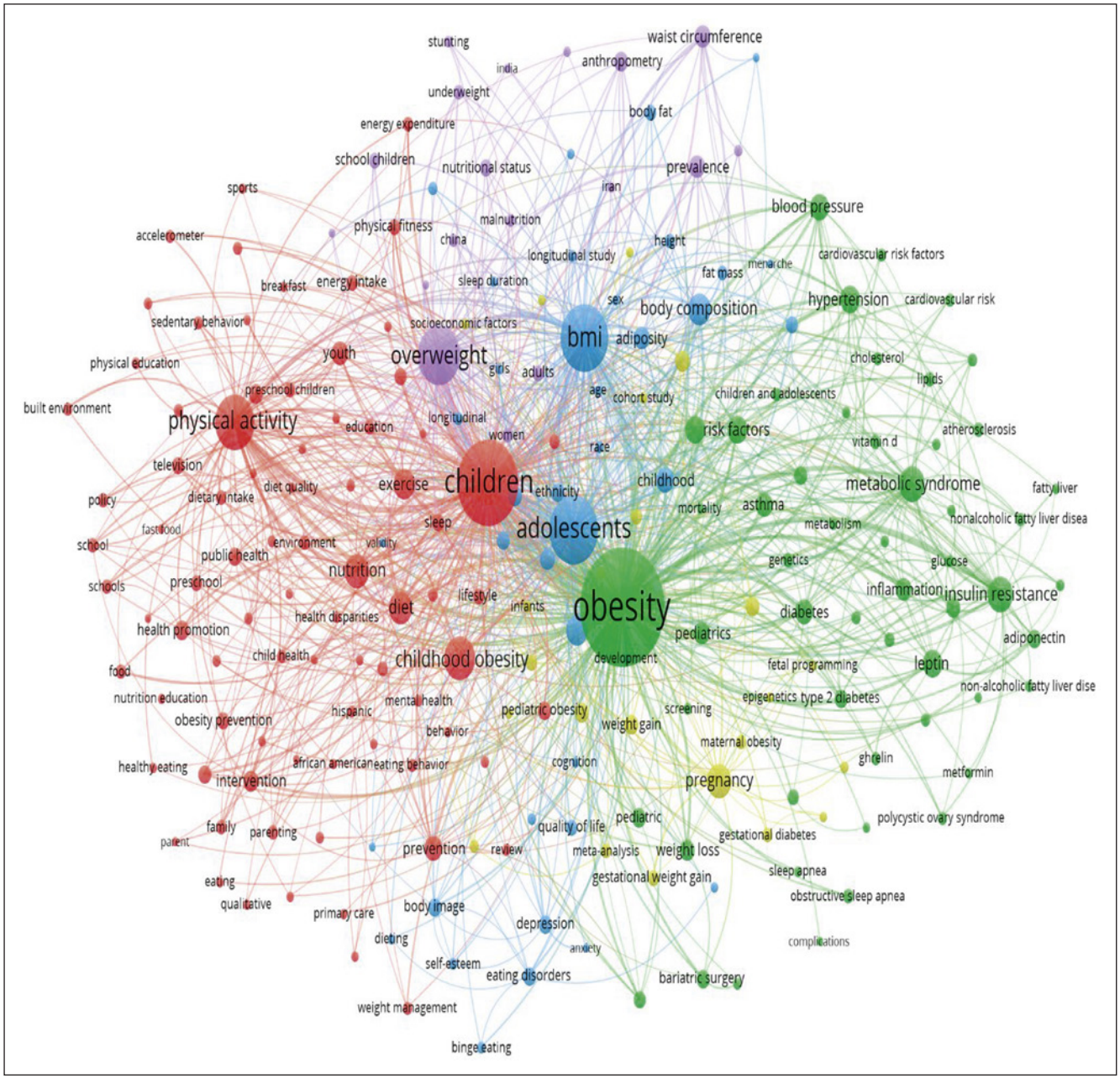

Fig. 6. Co-occurrence of authors' keywords.

its relation to the physical and mental health of children and adolescents, while research on interventions, especially large-scale, contextualized measures, is still limited.

Our results highlighted that the USA were the global knowledge hub in the field of childhood obesity, and the strongest collaborations worldwide were between the USA, Australia, England, and Canada, which is similar to the results of previous studies in different research areas [29, 30]. This may be explained by the fact that there was a positive relationship between a high prevalence of obesity and a high socioeconomic status of the population among high-income countries compared to low- and middle-income countries [1, 2].

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Moreover, the period from 2000 until now witnessed a significant growth of the number of publications in the field of childhood obesity. The prevalence of overweight and obesity also increased dramatically in this period due to the rise in food consumption, nutritional transition [31], and marketing by the food industry [32]; for instance, the overconsumption of fast-food and sugary products, increasing total daily calorie intake, is notoriously correlated to a rising BMI [33]. In addition to diet, urbanization was a factor contributing to the growth of childhood obesity, including a sedentary lifestyle, reduced physical activities, and the rapid proliferation of the Internet [34, 35].

In 2015, at the global level, a high BMI (>30) contributed to approximately 36% of DALYs and excess weight was related to 120 million (84–158 million) DALYs among adults [3]. However, in several countries, although the DALYs related to excess weight were high, the research output was not highly correlated. Although the WHO reported that in 2016 about half of the children with excess weight lived in Asia, the partnerships of cluster cooperations between Northern America, Western Europe, and East and South Asia might not be sufficient. This may create gaps in the global network literature due to the demands of understanding contextual factors and multilevel sociobiological determinants. Therefore, it is necessary to improve local research capacities and international research collaborations in countries hit hard by the obesity epidemic. Although science is on the rise in developing countries, their governments need to "fully support" the value of science to catch up with the developed world [36]. Also, multinational research networks involving different cultures, geographical areas, and socioeconomic subgroups should be strengthened.

This is the first bibliometric analysis of the global childhood obesity literature. Bibliometric and other, similar methods have been utilized for showing trends in different research fields using reliable, practical methods that measure, evaluate, and analyze scientific products [18, 19]. In our data set, the approaches to childhood obesity in the current publications chiefly focused on prevalence, classification, risk factors for childhood obesity, and consequences related to metabolic syndrome. We also found that a small number of studies within the data set shifted their focus to the effect of obesity on psychology such as depression, anxiety, eating disorders and body image, and self-esteem. Depression and obesity among children are two primary public health issues. Several previous studies have revealed a significant association of obesity with depression and with depressive symptoms among adolescent [37, 38]. Obesity may not directly result in depression but be related to experiences of shame and social isolation, which can lead to depression [38, 39]. However, because little attention has been paid to determining the prevalence of mental health issues among obese children, as well as to effective interventions, we suggest that more evidence regarding the effect of obesity on mental health should be gathered. In terms of prevention, most of the methods were based on increasing physical activity, promoting a healthy diet, and implementing educational programs. Furthermore, in our data set, when determining the 218 keywords with a minimum number of 100 appearances, only a small number of studies mentioned interventions based on the Internet. Previous research has highlighted the effectiveness of Internet-based obesity intervention programs among adolescents [40, 41]. Moreover, the relationships of obesity to mental health and wellness have not been fully investigated by the scientific community [42]. Obesity and mental health traditionally are treated separately; however, the relationship between them is bidirectional. Depression causes inactivity and thereby increases obesity. Obese individuals are frequently targeted for bullying at school, causing an increase in depressive symptoms [43].

Several limitations of our study should be considered. First, we only used the WoS database to collect scientific papers. Thus, there may be articles not provided by WoS which may influence the findings of our study. Second, because of the restriction of the scope of the search, we only included research articles and review articles; we excluded meeting abstracts, books, book

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chapters, and letters, which may have affected our results. We also excluded publications that were not written in English. Third, the analysis of occurrence and co-occurrence of keywords was based on the chosen keywords, and this can cause bias in terms of WoS-indexed papers.

In conclusion, this study presents the global research trends and developments in the field of childhood obesity. In addition, it highlights the needs for improving international and local research capacities and collaborations to accelerate knowledge production and translation into contextualized and effective childhood obesity prevention.

Statement of Ethics

The authors have no ethical conflicts to disclose.

Disclosure Statement

The authors have no conflicts of interest to declare.

Author Contributions

Bach Xuan Tran, Giang Hai Ha, Kim Anh Dang, Huong Thi Le, Carl A. Latkin, Long Hoang Nguyen, Cyrus S.H. Ho, and Roger C.M. Ho: conceptualization; Bach Xuan Tran, Giang Hai Ha, Kim Anh Dang, Huong Thi Le, Carl A. Latkin, Long Hoang Nguyen, Cyrus S.H. Ho, and Roger C.M. Ho: formal analysis; Bach Xuan Tran and Giang Hai Ha: investigation; Bach Xuan Tran, Giang Hai Ha, Kim Anh Dang, Huong Thi Le, Carl A. Latkin, Long Hoang Nguyen, Cyrus S.H. Ho, and Roger C.M. Ho: methodology; Bach Xuan Tran, Giang Hai Ha, Kim Anh Dang, Huong Thi Le, Carl A. Latkin, and Long Hoang Nguyen: project administration; Bach Xuan Tran, Giang Hai Ha, Kim Anh Dang, Huong Thi Le, Carl A. Latkin, Long Hoang Nguyen, Cyrus S.H. Ho, and Roger C.M. Ho: writing – original draft; Bach Xuan Tran, Giang Hai Ha, Kim Anh Dang, Huong Thi Le, Carl A. Latkin, Long Hoang Nguyen, Tu Huu Nguyen, Tung Hoang Tran, Cyrus S.H. Ho, and Roger C.M. Ho: writing – review and editing.

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