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A bibliometric technique for analyzing trends in public health research

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ABSTRACT

This study aims to assess the literature on public health concerning different bibliometric laws and factors. The Scopus citation database was utilized to collect bibliographic data for 372,260 public health publications published between 2000 and 2015. The research findings revealed that the majority of research output is published as articles (64.22%); The United States generated one-third of all publications, and the majority of public health articles were written by authors connected to the US "Centers for Disease Control and Prevention"; English makes up 89.22% of all research output, followed by French (2.65%), Spanish (2.34%), and German (2.03%); The UK-based journal *Lancet* ranked top of the list in producing 3,264 articles which account for 0.88% of total publications on public health. Since the percentage error is so little, Bradford's law of scattering was therefore found to fit the data set in the current investigation. Regarding public health, it has been noted that Zipf's Law roughly captures the relationship between rank (r) and frequency (f).

KEYWORDS

Bibliometric study; Public health; Bangladesh; Scopus database; Bradford's law of scattering; Zipf's Law of word frequencies

1 Prelude

The term "bibliometric" coined by Pritchard in 1969 to refer to the applying statistical techniques to books and other communication mediums, refers to the quantifiable characteristics of the arrangement, dissemination, and use of recorded information (Tague-Sutcliffe, 1992). It is currently widely employed as a method to evaluate the progress of any subject or subjects by arranging information using advanced statistical techniques, such as citations, author affiliations, keywords, concepts imparted, and procedures engaged for published studies in the subjects (Koseoglu et al., 2016). Bibliometric techniques have been applied in numerous studies to illustrate the trends in subject growth, the evolution of a country, institution, or university's output, the expansion of one or more journals or proceedings, the output of individual researchers or scientists, indicators, laws, and BIWS (bibliometric, informetric, webometric and scientometric) research principles, etc. on a global scale (e.g., Islam et al., 2021; Huang et al., 2015; Koseoglu et al., 2016; Jacobs, 2006; Geetha & Kothainayaki, 2019; Kevin et al., 2009; Merigó & Núñez, 2016; Kumaragurupari et al., 2010; Kademani & Kalyane, 1996; Hofer et al., 2010; Glänzel, & Schoepflin, 1999).

Researchers can conduct thorough and quantitative overviews of a particular topic with the help of the bibliometric technique, which has advantages over other literature review methods. These advantages include insights into knowledge production patterns, quantitative analysis of bibliographic data, historical and geographical trends, and systematic study of interdisciplinary

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research and curricular structures (Rúbio & Gulo, 2016; Herzog, et al., 2022). The best technique for evaluating the results of macro research is bibliometrics. Innovation is sustained by research, and this is one of the primary factors causing economic growth. Governments must therefore be able to estimate research performance to determine the true return on their research investments (Sethukumari, 2015). The status of research in the nation, its areas of strength and weakness, the volume and caliber of research output, and the dynamics of research across institutions, sectors, geographic areas, and subjects are all examined using bibliometric analysis. Policymakers and science planners may find this kind of study helpful in gaining broad perspectives on the nation's research infrastructure.

2 Public health

Health is not just the absence of sickness or infirmity, it also includes a condition of whole physical, mental, and social well-being (WHO, 1946). According to the Institute of Medicine (US) Committee for the Study of the Future of Public Health (1988) research, public health refers to the societal strategy for preserving and advancing health. Public health generally aims to enhance the well-being of communities through social (as opposed to individual) actions (Nurunnabi, et al., 2010). The core idea behind several intricate operations is what public health is, not how it is worded. Public health professionals were asked to indicate what public health meant to them in a symposium ("What Is Public Health", 1928), and the summarized result of their thinking related to public health includes the following:

- The improvement of living conditions, an increase in lifespan, the prevention of disease, and adaptation of man to his environment;
- The causes and consequences of health and disease are both addressed by public health;
- These goals are attained by both individuals and social groupings;
- The knowledge-related factors involve biology, chemistry, education, medicine, engineering, nursing, and the law;
- Through the initiatives of people of all ages, as well as the support of government and nonprofit organizations, public health is both a science and an art.

Activities aimed at promoting health, preventing disease, and extending life expectancy for the general public are referred to as public health. Thus, ensuring that individuals have the conditions necessary to be healthy is the primary goal of public health. Two different studies conducted by Jakovljevic & Ogura (2016) and Porter (1999) found the changing background of public health, has been molded by the advancement of illnesses. Over the past few decades, the focus of health research has shifted from studying hygienic reforms and infectious disease management to studying the effects of infectious illnesses and epidemics, as well as incorporating social action initiatives in the wake of epidemic disasters. As a result, the field of public health research has widened and enlarged to include a variety of academic fields, such as the study of health economics and the social and political aspects of health (Merigó & Núñez, 2016). Regional interactions and cooperation for health as well as the establishment of public health action priorities are examples of initiatives related to public health (Callahan & Jennings, 2002).

3 Bibliometric laws and standards

Several bibliometric laws are applied to evaluate applicability across various disciplines. There are three that are most common worldwide: Lotka's inverse square law, Bradford's law of scattering, and Zipf's law of word frequencies. Two factors (Çiftçi, et al., 2016) make these laws important since they impact the productivity of the field and publications: i) Researchers can assess and comprehend work and publications more effectively because of quantitative indicators; ii) A law can assist researchers in formulating a hypothesis to account for the existence of a given pattern.

3.1 Lotka's law on author productivity (1926)

This is one of the most discussed methods in bibliometrics and allied fields. The inverse square law was first proposed by Lotka to describe the size-frequency distribution of objects (papers) over sources (authors). According to Lotka, roughly 1\n_{2} of authors who make a single publication are among the authors who make "n" contributions. Lotka observed that there is a negative correlation between the number of publications and the number of writers. About 60% of all publications on a certain topic are contributed by authors who make single contributions. This law can be used to quantify scientific productivity in several phenomena (Friedman, 2015; Tague-Sutcliffe, 1992; Pao, 1985).

3.2 Bradford's law on journal productivity (1934)

Bradford's law stipulates that papers on a particular "subject" are spread (scattered) by a specific mathematical function, meaning that an increase in papers on a subject necessitates an increase in journals or other information sources. The Bradford multiplier n determines the approximate ratio of the number of journals that produce almost equal amounts of articles, which is 1: n: n^2. According to Bradford's law, a tiny core of journals, for instance, has the same number of articles on a given topic as a much greater number of journals, n, which again has the same number of papers as n^2 journals (Hjørland & Nicolaisen, 2005). This law of dispersion explains how journals and the papers they publish are related quantitatively. Bradford made two theoretical contributions: the first is a cumulative log-linear form of the rank frequency distribution, and the second is the notion of a geometric series that shows how many journals are added to the nucleus and surrounding zones for a given subject area, with each zone and the nucleus having an equal number of papers but fewer papers per journal (Sudhier & Abhila, 2011; Sudhier, 2010; Tague-Sutcliffe, 1992).

According to Bradford's Law of Scattering, three zones, each with an equal number of articles, can be formed from journals that are sorted according to the diminishing productivity of their articles on a particular topic. One-third of the total articles are found in Zone 1, also known as the core or nucleus zone, which is the most productive zone. Zone 2, which is a fairly prolific zone, has the same amount of articles but more journals than Zone 1. Zone 3, a low-productivity zone considered a peripheral zone, has more journals than Zone 2 which has the same amount of articles. The number of journals in the core has a numerical connection of constant "n" to the first zone (Zone 2) and a connection of "n^2" to the following zone (Zone 3) (Singh & Bebi, 2014). Bradford described the connection between the zones as

$$1:n:n^2$$

Bradford articulated his statement verbally. Brookes, Vickery, and Leimkuhler subsequently proposed various versions of Bradford's law, known as graphical formulation, as Bradford did not provide a mathematical formulation of his statement. For example, Brookes proposed the following linear relation to characterize the scattering phenomenon as follows: F(x) = a + b log x, where "a" and "b" are constants and F(x) represents the total number of references found in the first x most prolific journals. This is the version of Bradford's Law that is most frequently applied (Sudhier, 2010).

3.3 Zipf's law with word frequency (1949)

Zipf's law ranks the frequency of phrases from most common to least common using statistical methods. In a huge corpus distribution across types, he constructed distributions for a rank frequency and a size frequency for the word tokens. He exposed that the frequencies of some words are inversely related to their ranks in specific data sets. Zipf's law is typically expressed algebraically as rf=c, where r stands for rank, f for frequencies and c for constant depending on the subject. However, the rule is most commonly known when it is represented graphically as log r + log f = log c, which is a mathematically comparable form (Tague-Sutcliffe, 1992; Fedorowicz, 1982; Wyllys, 1981; Rajneesh & Rana, 2015).

4 Literature review

Public health research has become increasingly significant in the national health policies of developing countries as they strive to tackle the high burden of disease and its unequal distribution, while also pursuing an ambitious goal of universal healthcare. But the state of public health research in the Indian subcontinent reflects the overall low priority given to public health (Kalita et al., 2015). Public health research in this region is significantly under-represented and needs strategic planning, investment, and resource support to bring about a positive change in research output, and consequently to promote healthier lives for its population (Sadana et al., 2004). Between 2000 and 2015, global authors produced 372,260 literature on public health (Islam et al., 2021). Bangladeshi authors contributed 871 publications, accounting for 0.23% of the global output, with a productivity per author (PPA) of 0.31 compared with the global PPA of 0.49. In the same period, Indian writers produced 9,159 publications, contributing 2.46% of the world's public health literature (Islam et al., 2022) - a decline from a 2004 study that reported their contribution as less than 3.5% (Dandona et al., 2004). Pakistani authors contributed 1,664 publications, making up 0.45% of the global total (Islam et al., 2022). This comparative picture highlights the varying levels of public health research contributions from India, Pakistan, and Bangladesh, with India leading in absolute numbers but experiencing a relative decline, while Pakistan and Bangladesh have smaller yet significant contributions.

A study based on ISI Web of Science publications reported that between 1991 and 2005, African countries produced 1,213 publications on public health, with 1,086 of these published as journal articles. The number of public health articles increased significantly from 28 in 1991 to 135 in 2005, marking a 382% increase in public health publications. During this period, 81% of the total publications came from just 13 countries, with notable contributions from South Africa (222), Kenya (93), Egypt (82), Nigeria (82), and Tanzania (78) (Chuang et al., 2011). A separate study using the Scopus database revealed that just seven African nations each published more than 800 public health-related publications: South Africa (4,637), Nigeria (2,059), Kenya (1,291), Egypt (1,154), Tanzania (923), Uganda (895), and Ethiopia (802). Remarkably, South Africa, Nigeria, and Kenya alone accounted for 2.15% of the world's total public health output. From 1991 to 2015, African countries' contributions to public health research were noteworthy, with the total number of publications rising from 28 in 1991 to 135 in 2005, and contributions from only three countries (South Africa, Nigeria, and Kenya) reaching 7,987 publications by 2015 (Islam, 2018). Over the past 25 years, African scholars have conducted a notably greater amount of study on public health.

What has driven this trend? The rise might have been caused by several things. First off, the World Health Organization's 1987 worldwide reaction to the AIDS epidemic most likely resulted in increased funding for public health research in Africa in the 1990s (Mann et al., 1992). Furthermore, in the 1980s, donor organizations such as the World Bank and the International Monetary Fund began directing money through universities, local and international non-governmental organizations which changed the way public health research was carried out in Africa (Chuang et al., 2011). Moreover, greater strategic funding for African public health research and development might result in advances in illness prevention and control that would benefit the continent as well as the whole community (Gombe, 2024). Historically, African nations have often relied on outside academics to address public health concerns. However the importance of local universities and research centers in providing locally generated answers to these issues is now being recognized more and more. Increasing research capacity in Africa helps local specialists better tackle the unique problems facing public health in the continent (Sindi, 2023).

Europe makes a substantial contribution to the literature on global public health research, despite some obvious regional differences. When it comes to the number of publications about public health, the United Kingdom and the Nordic countries lead the way, while other bigger European countries publish comparatively fewer articles than their populations. In several Eastern European nations, the output of public health research is especially poor by all measures. Furthermore, on average, less than 100 publications are made annually in 15 of the 28 European nations (Clarke et al., 2007). Between 2000 and 2015, the United Kingdom contributed over 10% (38,313 publications) of the world’s public health research output. France and Germany also made

significant contributions, each accounting for over 3% of the global output. In contrast, countries like Poland, Austria, Croatia, the Czech Republic, and Hungary contributed less than half a percentage each to the world's public health research output. This highlights the substantial variation in public health research productivity across European countries (Islam, 2018).

The United States is consistently at the forefront of public health research, followed by the United Kingdom, Canada, China, France, Australia, the Netherlands, Germany, Italy, and Japan. According to a survey done between 2000 and 2012, the United States did very well in publishing, with 28,889 research articles—roughly three times as many as the second-most prolific nation. Authors from the United States published 43% of all articles throughout the entire time, while writers from Canada authored 6% of them (Donner et al., 2015). China and Japan are the two Asian superpowers that rank among the most productive nations in the region, along with India. China produced 8,586 public health documents between 2000 and 2015, accounting for 2.31% of the global total. Japan (4,921) contributes 1.32% of the global production on public health and is ranked 15th out of all countries in terms of the total number of papers generated during the duration. Australia and Brazil, ranked fourth and fifth in the globe, respectively, published 18,002 and 12,953 public health papers (Islam, 2018).

5 Research problems and objectives

Since research is a complicated endeavor, it is frequently necessary to analyze the results, which are typically published for a variety of purposes as books, journal articles, reports, conference proceedings, etc. The following are some of the justifications for bibliometric analysis in public health literature:

- the progress and potential growth of the topic;
- rising recognition of the importance of research, and financing for research projects;
- determining the priorities for future research by evaluating the research's strengths and weaknesses;
- determining which journal to submit an article for publication by identifying the top publication in this field;
- finding the best research and the top researchers based on impact factors;
- finding possible partners, etc.

This study was created with the broad goal of evaluating the development pattern, Bradford's laws of scattering, and Zipf's law of word occurrence of public health literature that was indexed in the Scopus database between 2000 and 2015. To accomplish this, the following specific objectives were set up:

a) To analyze public health literature using various parameters, including literature produced by affiliated institutions, country, document type, author, subject, and sources of publications;
b) To measure how articles on public health are scattered across journals using Bradford's laws of Scattering;
c) To show the relation between the rank of words and the frequencies of their appearance using Zipf's law of word occurrence.

6 Research methodologies

The Scopus citation database was utilized to gather bibliographic data on public health literature published between 2000 and 2015. Throughout the study period, 372,260 papers on public health were taken from the database. The search results were obtained from the Scopus database in two ways: a detailed search result with citation information that included subfields such as author, title, year, source title, volume, issue, pagination, citation information, etc.; and a year-wise search result that included subfields such as year, number of results, author name, subject area, document type, source title, keyword, affiliation, country, source type, and language. The productivity of public health research was examined to see if Bradford's law of scattering

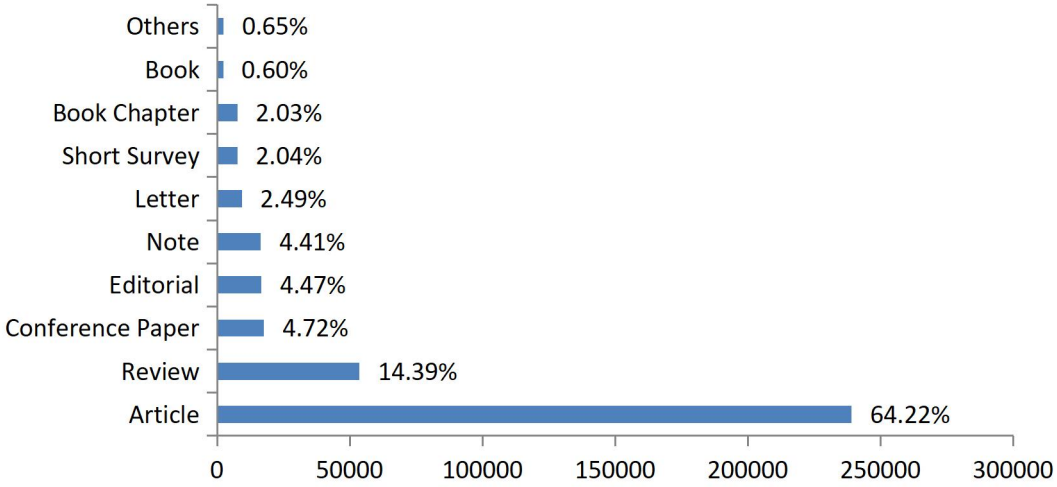
applied to data from public health journals around the world. Additionally, using Zipf's law of word occurrence, the correlation between a word's rank and frequency of presence was also observed.

7 Results

7.1 Document types

Research output normally appears in different formats, for example, articles, book chapters, conference proceedings, etc. The Scopus database also covers a variety of publication formats of research output. During this search on public health, all types of documents supported by the Scopus database were included.

Figure 1 shows the types of documents together with the rate of percent covered under the present study. The largest percentage of the research output is published in the form of article (64.22%), followed by review (14.39%) and conference paper (4.72%). “Book chapter” and “Book” were very small in quantity (2.63%).



	Article	Review	Conference Paper	Editorial	Note	Letter	Short Survey	Book Chapter	Book	Others
Number of Document	23906	53550	17562	16646	16400	9256	7598	7548	2236	2404

Figure 1 Document type-wise distribution of public health literature

7.2 Major subject areas

A total of 372,260 research outputs were published in various macro-subject areas within public health during 2000-2015. “Medicine”, “Social Sciences”, “Nursing”, “Biochemistry, Genetics and Molecular Biology”, “Environmental Science”, “Immunology and Microbiology”, “Pharmacology, Toxicology and Pharmaceutics”, “Agricultural and Biological Sciences”, and “Health Professions” are the top 10 subject fields covering 83.33% of total publications (Table 1).

Table 1 Subject area-wise distribution

Subject areas	Number of publications	Percentage (%)
Medicine	265,526	49.08
Social Sciences	43,400	8.02
Nursing	30,549	5.65
Biochemistry, Genetics and Molecular Biology	24,576	4.54
Environmental Science	23,267	4.30

Immunology and Microbiology	18,908	3.50
Pharmacology, Toxicology and Pharmaceutics	16,816	3.11
Agricultural and Biological Sciences	16,803	3.11
Health Professions	10,945	2.02
Psychology	10,708	1.98
Engineering	9,848	1.82
Arts and Humanities	7,204	1.33
Veterinary	5,506	1.02
Computer Science	4,968	0.92
Neuroscience	4,909	0.91
Business, Management and Accounting	4,557	0.84
Economics, Econometrics and Finance	4,354	0.80
Dentistry	4,170	0.77
Chemistry	3,418	0.63
Earth and Planetary Sciences	3,392	0.63
Multidisciplinary	3,091	0.57
Chemical Engineering	2,796	0.52
Mathematics	2,121	0.39
Energy	1,827	0.34
Physics and Astronomy	1,689	0.31
Materials Science	1,118	0.21
Decision Sciences	962	0.18
Others	13,566	2.51
Total	540,994	100.00

7.3 Country-wise research output on public health

The countries which produced more than 800 publications on public health are presented in Table 2. It is observed from Table 2 that about one-third of the total publications were produced in the United States. More than half of the total publications were produced by the top four countries. China generated 8,586 public health documents at that time, ranking ninth globally. Among the SAARC countries, India ranked on the top position with a total of 9,159 publications (8th in the world ranking), which is followed by Pakistan with a total of 1,664 documents (37th in the world ranking). Bangladesh occupies 49th place with a total of 871 publications (49th in the world ranking).

Table 2 Country-wise publications on public health (countries with more than 800 publications were listed)

Rank	Country	Number of publications	Percentage (%)	Rank	Country	Number of publications	Percentage (%)
1	United States	116,418	31.27	27	Greece	2,260	0.61
2	United Kingdom	38,313	10.29	28	Thailand	2,167	0.58
3	Canada	18,692	5.02	29	Nigeria	2,059	0.55
4	Australia	18,002	4.84	30	Israel	1,983	0.53
5	Brazil	12,953	3.48	31	Hong Kong	1,977	0.53
6	France	12,431	3.34	32	Ireland	1,941	0.52
7	Germany	11,466	3.08	33	Portugal	1,897	0.51
8	India	9,159	2.46	34	Malaysia	1,869	0.50
9	China	8,586	2.31	35	Poland	1,814	0.49
10	Italy	8,305	2.23	36	Austria	1,679	0.45

Rank	Country	Number of publications	Percentage (%)	Rank	Country	Number of publications	Percentage (%)
11	Spain	8,217	2.21	37	Pakistan	1,664	0.45
12	Netherlands	7,229	1.94	38	Argentina	1,463	0.39
13	Switzerland	6,889	1.85	39	Colombia	1,448	0.39
14	Sweden	6,122	1.64	40	Singapore	1,400	0.38
15	Japan	4,921	1.32	41	Chile	1,307	0.35
16	South Africa	4,637	1.25	42	Kenya	1,291	0.35
17	Belgium	3,859	1.04	43	Saudi Arabia	1,186	0.32
18	Denmark	3,589	0.96	44	Croatia	1,172	0.31
19	Norway	3,324	0.89	45	Egypt	1,154	0.31
20	New Zealand	3,280	0.88	46	Czech Republic	1,018	0.27
21	Mexico	3,024	0.81	47	Tanzania	923	0.25
22	Turkey	2,801	0.75	48	Uganda	895	0.24
23	Iran	2,726	0.73	49	Bangladesh	871	0.23
24	South Korea	2,707	0.73	50	Hungary	808	0.22
25	Taiwan	2,690	0.72	51	Ethiopia	802	0.22
26	Finland	2,575	0.69				

7.4 Top 10 affiliated institutions on public health

Table 3 shows the list of the top 10 institutions the authors on public health are affiliated with. The authors affiliated with the Centers for Disease Control and Prevention of the USA produced the maximum number of papers on public health. The researchers of this institution published 1.20% of the total publication (1st in world ranking). London School of Hygiene & Tropical Medicine was placed in 2nd rank by producing 3,349 articles (0.90%). Organisation Mondiale de la Sante (World Health Organization) held 3rd place in the world ranking in producing public health-related literature (3,115, 0.84%).

Table 3 Top 10 affiliated institutions

Rank	Affiliated institutions	Country	Number of publications	Percentage (%)
1	Centers for Disease Control and Prevention	USA	4,457	1.20
2	London School of Hygiene & Tropical Medicine	UK	3,349	0.90
3	Organisation Mondiale de la Sante	Switzerland	3,115	0.84
4	University of Toronto	Canada	3,063	0.82
5	University of California, San Francisco	USA	2,994	0.80
6	The University of North Carolina at Chapel Hill	USA	2,776	0.75
7	Johns Hopkins Bloomberg School of Public Health	USA	2,752	0.74
8	Universidade de Sao Paulo - USP	Brazil	2,701	0.73
9	Harvard School of Public Health	USA	2,644	0.71
10	VA Medical Center	USA	2,641	0.71

7.5 Top 10 publication languages

The language of research output is also an interesting part to notice in the present study. Table 4 depicts the language-wise distribution of the records. English is the preferred language in scholarly communication. 89.22% of the total research output is written in English, which is followed by French (2.65%), Spanish (2.34%), and German (2.03%).

Table 4 Language-wise distribution

Rank	Language	Number of publications	Percentage (%)
1	English	332,134	89.22
2	French	9,872	2.65
3	Spanish	8,709	2.34
4	German	7,551	2.03
5	Portuguese	7,147	1.92
6	Italian	1,903	0.51
7	Russian	1,716	0.46
8	Chinese	1,691	0.45
9	Japanese	1,352	0.36
10	Polish	1,117	0.30

7.6 Source type of publication

It is obvious from Table 5 that 93.91% of the total publications on public health were journal articles. Only 2.66% and 1.83% of the total publications were books and conference proceedings.

Table 5 Source type of publication

Source type	Number of publications	Percentage (%)
Journals	349,584	93.91
Books	9,917	2.66
Conference Proceedings	6,808	1.83
Book Series	3,697	0.99
Trade Publications	1,988	0.53
Others	266	0.07
Total	372,260	100.00

7.7 Journal productivity

7.7.1 Core journals

The journal which has the highest percentage of articles about the subject is called a core journal. The top 50 core journals on public health literature are presented in Table 6.

The UK-based journal *Lancet* ranked top of the list in producing 3,264 articles which account for 0.88% of total publications on public health during the period 2000-2015. The *American Journal of Public Health* ranked 2nd with 3,234 articles, while *PLoS One* ranked 3rd with 3,117 articles.

Table 6 Top 50 journals on public health literature

Rank	Name of journals	Number of publications	Percentage (%)
1	*Lancet*	3,264	0.88
2	*American Journal of Public Health*	3,234	0.87
3	*PLoS One*	3,117	0.84
4	*Health Service Journal*	2,713	0.73
5	*BMC Public Health*	2,535	0.68
6	*American Journal of Epidemiology*	2,128	0.57
7	*Public Health*	2,117	0.57
8	*Social Science And Medicine*	2,000	0.54
9	*Pharmaceutical Journal*	1,799	0.48
10	*European Journal of Public Health*	1,568	0.42

Rank	Name of journals	Number of publications	Percentage (%)
11	*Public Health Reports*	1,566	0.42
12	*Environmental Health Perspectives*	1,423	0.38
13	*Medical Journal of Australia*	1,324	0.36
14	*Canadian Journal of Public Health*	1,300	0.35
15	*American Journal of Preventive Medicine*	1,261	0.34
16	*Scandinavian Journal of Public Health*	1,222	0.33
17	*Bulletin of The World Health Organization*	1,182	0.32
18	*BMJ Clinical Research Ed*	1,146	0.31
19	*Vaccine*	1,129	0.30
20	*Australian And New Zealand Journal of Public Health*	1,099	0.30
21	*Health Affairs*	1,093	0.29
22	*Journal of Epidemiology And Community Health*	1,059	0.28
23	*BMJ Online*	1,043	0.28
24	*Journal of Public Health Management And Practice*	1,042	0.28
25	*Science*	1,036	0.28
26	*Nature*	1,030	0.28
27	*Pediatrics*	1,030	0.28
28	*International Journal of Environmental Research And Public Health*	1,017	0.27
29	*Ciencia E Saude Coletiva*	981	0.26
30	*Cadernos De Saude Publica*	970	0.26
31	*South African Medical Journal*	964	0.26
32	*BMC Health Services Research*	954	0.26
33	*New England Journal of Medicine*	905	0.24
34	*Health Policy*	880	0.24
35	*Health Promotion Practice*	876	0.24
36	*Public Health Nutrition*	867	0.23
37	*International Journal of Epidemiology*	847	0.23
38	*New Zealand Medical Journal*	834	0.22
39	*British Medical Journal*	815	0.22
40	*Emerging Infectious Diseases*	780	0.21
41	*Preventing Chronic Disease*	771	0.21
42	*Environmental Science And Technology*	769	0.21
43	*JAMA Journal of The American Medical Association*	767	0.21
44	*Revista Panamericana De Salud Publica Pan*	758	0.20
45	*Journal of The American Medical Association*	752	0.20
46	*Journal of Public Health*	727	0.20
47	*MMW Fortschritte Der Medizin*	718	0.19
48	*Clinical Infectious Diseases*	715	0.19
49	*Nursing Times*	706	0.19
50	*Science of The Total Environment*	695	0.19

7.7.2 Application of Bradford's law of scattering into the journals of public health

Bradford's Law of scattering explains the distribution or dispersion of articles in journals on a certain topic (Viju, 2013). Libraries and information centers can make use of Bradford's law of

scattering in choosing key journals within a certain topic area. Bradford's law of scattering has already been the subject of several investigations worldwide (Singh & Bebi, 2014; Sudhier, 2010; Nicolaisen & Hjorland, 2007; Vickery, 1948). In the current study, 160 journals were split into three areas to calculate the mathematical interpretations of Bradford's law. Appendix 1 displays the total number of journals and the associated number of articles in descending order, and Table 7 displays the distributions of journals and the number of papers that belong to each zone, as well as the figures for Bradford's multipliers (Figure 2).

Table 7 shows that every set of journals comprised one-third of all articles (108,745/3= about 36,248.33 articles in each zone). Consequently, 36,028 articles were included by 19 journals, followed by 45 journals with coverage of 36,151 articles, and 96 journals that included 36,566 articles. Bradford's multiplier is the proportion of the journal of any group to the number of journals of the preceding zone. The mean multiplier in the nucleus zone is 2.25, and there are 19 journals in the zone 1. Bradford's verbal formulation with this value may be stated as follows:

$$1: n: n^2 = 19: 19 \times 2.25: 19 \times 2.25^2 = 19: 42.75: 96.18$$

And the percentage of errors is $\frac{157.93-160}{160} \times 100 = 1.29\%$. Due to the minimal percentage of variation, Bradford's law of dispersion was found to be appropriate for the data set in the current investigation.

Table 7 Bradford's zone-wise distribution of journals of public health

Zone	Publications (%)	Journals (%)	*n*
1	36,028(33.13)	19(11.88)	--
2	36,151(33.24)	45(28.13)	2.37
3	36,566(33.63)	96(60.00)	2.13
Total	108,745(100.00)	160(100.00)	2.25

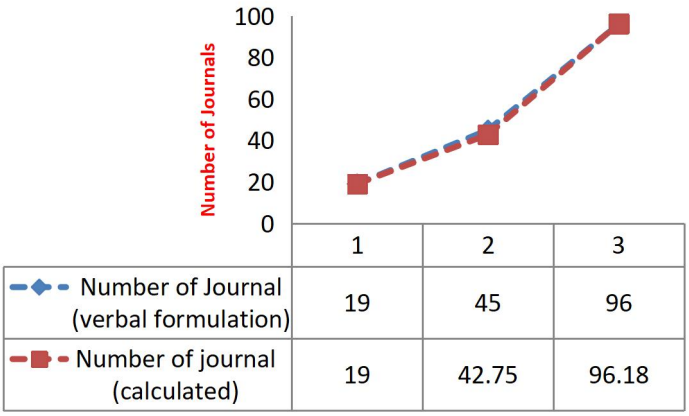


Figure 2 Zone-by-zone journal distribution using Bradford's scattering law

7.7.3 Application of Zipf's law on keywords of public health literature

When Zipf's law was applied to the public health literature's keywords, 164 terms came up 3,241,857 times. The chosen keywords appeared more than 6,768 times. Appendix 2 displays the computed values of Log r, Log f, and Log c together with the frequency and rankings of the keywords. From 2000 to 2015, the term "Human" had the highest frequency (257,256 times), ranking first in the public health literature. The other most often occurring terms were Humans (233,479), Article (192,641), Public Health (107,418), etc. The following graphs illustrate Zipf's Law by plotting based on these data.

If we compare the frequencies (f) with rank (r), we find a hyperbolic curve. There is a proportionate inverse link between rank and frequency (Figure 3).

The rank and frequency log values appeared to be roughly consistent throughout the full data set (Figure 4). Regarding public health, it has been noted that Zipf's Law roughly captures the link between rank (r) and frequency (f).

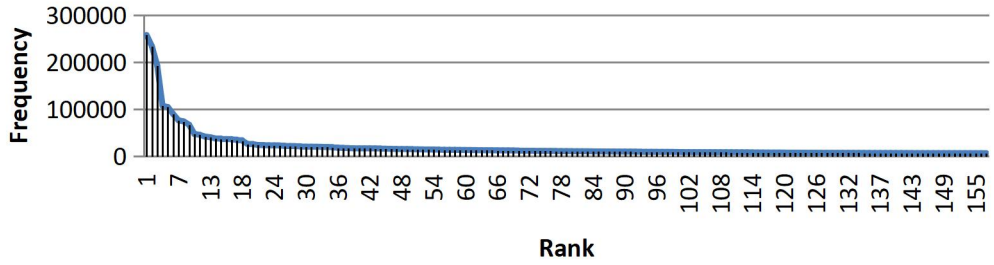


Figure 3 Zipf's law: Rank vs. Frequency

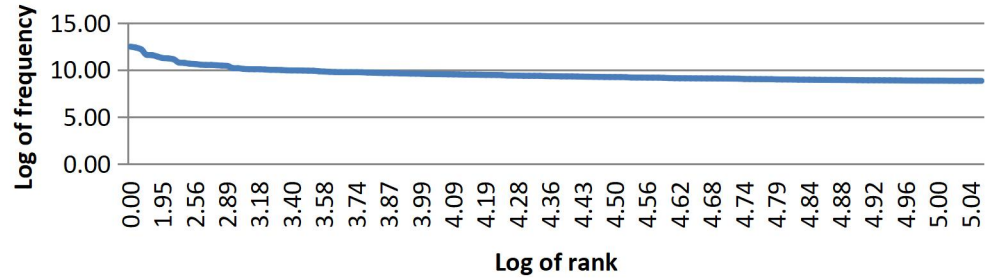


Figure 4 Log of rank and frequency chart on keywords

8 Conclusion

To show how subjects have changed over time, academics have been scrutinizing the epistemology, knowledge domain, and/or intellectual structure of it. To evaluate the evolution of a particular subject, bibliometric analysis is being utilized more and more to map the structure and growth of scientific domains or subjects (Koseoglu et al., 2016). Several characteristics were used in our study to evaluate the public health literature, such as the distribution of document types, countries, subjects, most prolific institutions, etc. Some bibliometric laws, such as Bradford's law of scattering and Zipf's law of word occurrence, have also been tested in public health literature. It was discovered that public health writers' research production adhered to Bradford's law of scattering when applied to data from public health publications worldwide. Additionally, it was noted that Zipf's law roughly represented the correlation between the frequency and rank of public health-related phrases.

Although offering insightful information on the distribution and trends in public health research, the current study still has several shortcomings. The study's coverage of papers from 2000 to 2015 means that, given the field's rapid improvements and shifting goals, it may not accurately reflect the most recent trends and breakthroughs in public health research. The Scopus citation database is the only source of data used in this study. According to the study, 89.22% of research output is produced in English. This suggests a substantial language bias that might distort the overall results by ignoring crucial public health research that has been published in languages other than English. The dominant position of the US "Centers for Disease Control and Prevention" and the country's research output may eclipse the contributions of other locations. There may be a lack of coverage of global public health concerns as a result of this local emphasis. Utilizing bibliometric laws like Zipf's and Bradford's law yields a quantitative assessment of the distribution and production of research. These regulations, however, do not take into consideration the qualitative effects of research, such as how it affects practice, policy, or other studies. According to the study, 64.22% of the research output is published as papers. This approach might leave out important channels

for disseminating public health research, such as books, conference proceedings, or grey literature, giving just a partial view of the field. These restrictions imply that although the paper provides a wide picture of current trends in public health research, care should be taken when interpreting the results and more studies may be required to fill up these gaps.

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Appendix 1 Distribution of journals and related papers in compliance with Bradford's laws

Number of articles	Total number of journals	Total number of articles	Cumulative articles
3,264	1	3,264	3,264
3,234	1	3,234	6,498
3,117	1	3,117	9,615
2,713	1	2,713	12,328
2,535	1	2,535	14,863
2,128	1	2,128	16,991
2,117	1	2,117	19,108
2,000	1	2,000	21,108
1,799	1	1,799	22,907
1,568	1	1,568	24,475
1,566	1	1,566	26,041
1,423	1	1,423	27,464

Number of articles	Total number of journals	Total number of articles	Cumulative articles
1,324	1	1,324	28,788
1,300	1	1,300	30,088
1,261	1	1,261	31,349
1,222	1	1,222	32,571
1,182	1	1,182	33,753
1,146	1	1,146	34,899
1,129	1	1,129	36,028
1,099	1	1,099	37,127
1,093	1	1,093	38,220
1,059	1	1,059	39,279
1,043	1	1,043	40,322
1,042	1	1,042	41,364
1,036	1	1,036	42,400
1,030	2	2,060	44,460
1,017	1	1,017	45,477
981	1	981	46,458
970	1	970	47,428
964	1	964	48,392
954	1	954	49,346
905	1	905	50,251
880	1	880	51,131
876	1	876	52,007
867	1	867	52,874
847	1	847	53,721
834	1	834	54,555
815	1	815	55,370
780	1	780	56,150
771	1	771	56,921
769	1	769	57,690
767	1	767	58,457
758	1	758	59,215
752	1	752	59,967
727	1	727	60,694
718	1	718	61,412
715	1	715	62,127
706	1	706	62,833
695	1	695	63,528
670	1	670	64,198
658	1	658	64,856
655	1	655	65,511
650	1	650	66,161
645	1	645	66,806
629	1	629	67,435
624	1	624	68,059
622	1	622	68,681

Number of articles	Total number of journals	Total number of articles	Cumulative articles
621	1	621	69,302
600	1	600	69,902
585	1	585	70,487
573	1	573	71,060
566	1	566	71,626
553	1	553	72,179
551	1	551	72,730
541	1	541	73,271
533	2	1066	74,337
530	1	530	74,867
524	1	524	75,391
522	2	1044	76,435
519	1	519	76,954
517	1	517	77,471
495	1	495	77,966
482	2	964	78,930
480	1	480	79,410
465	2	930	80,340
463	1	463	80,803
454	1	454	81,257
453	1	453	81,710
448	1	448	82,158
443	1	443	82,601
428	2	856	83,457
427	1	427	83,884
424	1	424	84,308
421	1	421	84,729
419	1	419	85,148
409	1	409	85,557
407	1	407	85,964
405	1	405	86,369
404	1	404	86,773
403	1	403	87,176
402	2	804	87,980
399	1	399	88,379
398	2	796	89,175
395	1	395	89,570
387	1	387	89,957
384	1	384	90,341
382	1	382	90,723
380	1	380	91,103
378	1	378	91,481
376	2	752	92,233
374	1	374	92,607
367	2	734	93,341

Number of articles	Total number of journals	Total number of articles	Cumulative articles
365	1	365	93,706
360	1	360	94,066
359	1	359	94,425
357	1	357	94,782
356	1	356	95,138
349	2	698	95,836
348	3	1044	96,880
346	1	346	97,226
342	2	684	97,910
340	1	340	98,250
338	1	338	98,588
337	1	337	98,925
335	1	335	99,260
334	1	334	99,594
331	1	331	99,925
328	1	328	1,00,253
327	1	327	1,00,580
324	1	324	1,00,904
323	1	323	1,01,227
322	2	644	1,01,871
320	1	320	1,02,191
317	1	317	1,02,508
314	1	314	1,02,822
312	1	312	1,03,134
311	2	622	1,03,756
306	1	306	1,04,062
302	1	302	1,04,364
301	1	301	1,04,665
300	2	600	1,05,265
299	1	299	1,05,564
296	1	296	1,05,860
294	1	294	1,06,154
290	1	290	1,06,444
289	2	578	1,07,022
288	2	576	1,07,598
287	3	861	1,08,459
286	1	286	1,08,745
Total	160	108,745	

Note: Journals that have at least 286 articles are considered for the current study.

Appendix 2 Highly used keywords on public health

Keywords	Frequency (f)	Rank (r)	Log of f	Log of r	C (log f+ log r)
Human	257,256	1	12.46	0.00	12.46
Humans	233,479	2	12.36	0.69	13.05
Article	192,641	3	12.17	1.10	13.27

Keywords	Frequency (f)	Rank (r)	Log of f	Log of r	C (log f+ log r)
Public Health	107,418	4	11.58	1.39	12.97
Female	104,434	5	11.56	1.61	13.17
Male	89,739	6	11.40	1.79	13.19
Adult	76,464	7	11.24	1.95	13.19
Priority Journal	74,043	8	11.21	2.08	13.29
United States	67,069	9	11.11	2.20	13.31
Review	47,398	10	10.77	2.30	13.07
Middle Aged	45,771	11	10.73	2.40	13.13
Adolescent	41,927	12	10.64	2.48	13.12
Controlled Study	40,538	13	10.61	2.56	13.17
Aged	37,899	14	10.54	2.64	13.18
Organization And Management	36,660	15	10.51	2.71	13.22
Major Clinical Study	36,600	15	10.51	2.71	13.22
Public Health Service	35,538	16	10.48	2.77	13.25
Health Care Policy	34,184	17	10.44	2.83	13.27
Child	33,232	18	10.41	2.89	13.30
Prevalence	26,224	19	10.17	2.94	13.11
Risk Factor	25,953	20	10.16	3.00	13.16
Risk Assessment	24,042	21	10.09	3.04	13.13
Health Survey	23,500	22	10.06	3.09	13.15
Nonhuman	23,336	23	10.06	3.14	13.20
Methodology	23,323	24	10.06	3.18	13.24
Risk Factors	22,620	25	10.03	3.22	13.25
Health Care Quality	21,915	26	9.99	3.26	13.25
Questionnaire	21,872	27	9.99	3.30	13.29
United Kingdom	21,375	28	9.97	3.33	13.30
Animals	20,664	29	9.94	3.37	13.31
Young Adult	20,504	30	9.93	3.40	13.33
Health Care Delivery	20,495	31	9.93	3.43	13.36
Health Promotion	20,305	32	9.92	3.47	13.39
Economics	19,987	33	9.90	3.50	13.40
Public Relations	19,800	34	9.89	3.53	13.42
Statistics	18,755	35	9.84	3.56	13.4
Questionnaires	18,168	36	9.81	3.58	13.39
Mortality	17,673	37	9.78	3.61	13.39
Health Service	17,243	38	9.76	3.64	13.4
Education	17,024	39	9.74	3.66	13.4
Standard	17,014	40	9.74	3.69	13.43
Health Program	17,002	41	9.74	3.71	13.45
Psychological Aspect	16,990	42	9.74	3.74	13.48
Government	16,851	43	9.73	3.76	13.49
Note	16,313	44	9.70	3.78	13.48
Health Policy	16,082	45	9.69	3.81	13.4
Editorial	15,771	46	9.67	3.83	13.4

Keywords	Frequency (f)	Rank (r)	Log of f	Log of r	C (log f+ log r)
Health Care Cost	15,512	47	9.65	3.85	13.50
Cross-Sectional Studies	15,481	48	9.65	3.87	13.52
Practice Guideline	15,411	49	9.64	3.89	13.53
Child, Preschool	14,982	50	9.61	3.91	13.52
Epidemiology	14,869	51	9.61	3.93	13.54
Attitude To Health	14,609	52	9.59	3.95	13.54
Infant	14,552	53	9.59	3.97	13.56
Legal Aspect	14,411	54	9.58	3.99	13.57
Health	13,974	55	9.54	4.01	13.55
Cross-sectional Study	13,820	56	9.53	4.03	13.56
Socioeconomics	13,774	57	9.53	4.04	13.57
Health Care	13,707	58	9.53	4.06	13.59
Health Education	13,540	59	9.51	4.08	13.59
National Health Programs	13,480	60	9.51	4.09	13.60
Health Care Planning	13,346	61	9.50	4.11	13.61
Incidence	13,087	62	9.48	4.13	13.61
Obesity	13,013	63	9.47	4.14	13.61
Medical Research	12,992	64	9.47	4.16	13.63
Great Britain	12,835	65	9.46	4.17	13.63
Socioeconomic Factors	12,732	66	9.45	4.19	13.64
Patient Care	12,695	67	9.45	4.20	13.65
Health Care Personnel	12,650	68	9.45	4.22	13.67
Human Immunodeficiency Virus	12,412	69	9.43	4.23	13.66
Health Care Organization	11,894	70	9.38	4.25	13.63
Health Care System	11,852	71	9.38	4.26	13.64
Pregnancy	11,783	72	9.37	4.28	13.65
Public Hospital	11,572	73	9.36	4.29	13.65
Preschool Child	11,556	74	9.35	4.30	13.65
Smoking	11,527	75	9.35	4.32	13.67
Inter professional Relations	11,501	76	9.35	4.33	13.68
Aged, 80 And Over	11,225	77	9.33	4.34	13.67
Health Knowledge, Attitudes, Practice	11,091	78	9.31	4.36	13.67
Decision Making	11,070	79	9.31	4.37	13.68
Health Status	10,887	80	9.30	4.38	13.68
Canada	10,871	81	9.29	4.39	13.68
Epidemic	10,846	82	9.29	4.41	13.70
Policy	10,719	83	9.28	4.42	13.70
Financial Management	10,531	84	9.26	4.43	13.69
Australia	10,476	85	9.26	4.44	13.70
Public Policy	10,376	86	9.25	4.45	13.70
Comparative Study	10,333	87	9.24	4.47	13.71
Health Services	10,207	88	9.23	4.48	13.71

Keywords	Frequency (f)	Rank (r)	Log of f	Log of r	C (log f+ log r)
Accessibility					
Animal	10,179	89	9.23	4.49	13.72
Clinical Trial	10,148	90	9.23	4.50	13.73
Demography	10,125	91	9.22	4.51	13.73
Attitude Of Health Personnel	9,991	92	9.21	4.52	13.73
World Health Organization	9,650	93	9.17	4.53	13.70
Information Processing	9,620	94	9.17	4.54	13.71
Sex Difference	9,596	95	9.17	4.55	13.72
Interview	9,543	96	9.16	4.56	13.72
Health Insurance	9,521	97	9.16	4.57	13.73
Treatment Outcome	9,517	98	9.16	4.58	13.75
Medical Education	9,312	99	9.14	4.60	13.74
Infant, Newborn	9,090	100	9.11	4.61	13.72
Infection Control	8,963	101	9.10	4.62	13.72
Letter	8,904	102	9.09	4.62	13.71
Follow Up	8,900	103	9.09	4.63	13.72
HIV Infections	8,853	104	9.09	4.64	13.73
Conference Paper	8,812	105	9.08	4.65	13.73
Organization	8,788	106	9.08	4.66	13.74
Health Personnel Attitude	8,739	107	9.08	4.67	13.75
Health Care Access	8,735	108	9.08	4.68	13.76
Health Behavior	8,702	109	9.07	4.69	13.76
Europe	8,672	110	9.07	4.70	13.77
Delivery Of Health Care	8,622	111	9.06	4.71	13.77
Outcome Assessment	8,573	112	9.06	4.72	13.78
Quality Of Life	8,496	113	9.05	4.73	13.78
Age	8,252	114	9.02	4.74	13.76
Politics	8,201	115	9.01	4.74	13.75
Environmental Exposure	8,148	116	9.01	4.75	13.76
National Health Service	8,111	117	9.00	4.76	13.76
Age Distribution	8,092	118	9.00	4.77	13.77
Disease Transmission	8,064	119	9.00	4.78	13.78
Ethics	7,894	120	8.97	4.79	13.76
Clinical Practice	7,847	121	8.97	4.80	13.77
Primary Health Care	7,837	122	8.97	4.80	13.77
Community Care	7,801	123	8.96	4.81	13.77
Vaccination	7,666	124	8.94	4.82	13.76
Statistics And Numerical Data	7,646	125	8.94	4.83	13.77
Program Evaluation	7,619	126	8.94	4.84	13.80
Public Opinion	7,560	127	8.93	4.84	13.77
Physician	7,509	128	8.92	4.85	13.77
Brazil	7,492	129	8.92	4.86	13.78

Keywords	Frequency (f)	Rank (r)	Log of f	Log of r	C (log f+ log r)
Morbidity	7,456	130	8.92	4.87	13.79
Interpersonal Communication	7,447	131	8.92	4.88	13.80
Health Hazard	7,434	132	8.91	4.88	13.79
Procedures	7,365	133	8.90	4.89	13.79
Time Factors	7,362	134	8.90	4.90	13.80
Disease Outbreaks	7,280	135	8.89	4.91	13.80
Germany	7,240	136	8.89	4.91	13.80
Mental Health	7,195	137	8.88	4.92	13.80
Population Surveillance	7,195	137	8.88	4.92	13.80
History	7,189	138	8.88	4.93	13.81
Retrospective Studies	7,155	139	8.88	4.93	13.81
Poverty	7,141	140	8.87	4.94	13.81
International Cooperation	7,102	141	8.87	4.95	13.82
Cooperative Behavior	7,055	142	8.86	4.96	13.82
Cooperation	6,979	143	8.85	4.96	13.81
Age Factors	6,966	144	8.85	4.97	13.82
Internet	6,942	145	8.85	4.98	13.83
Diabetes Mellitus	6,929	146	8.84	4.98	13.82
Cohort Analysis	6,917	147	8.84	4.99	13.83
Retrospective Study	6,915	148	8.84	5.00	13.84
Health Services Research	6,908	149	8.84	5.00	13.84
Disease Association	6,898	150	8.84	5.01	13.85
Hospitalization	6,858	151	8.83	5.02	13.85
Cardiovascular Disease	6,838	152	8.83	5.02	13.85
Hospitals, Public	6,816	153	8.83	5.03	13.86
Short Survey	6,813	154	8.83	5.04	13.87
Safety	6,810	155	8.83	5.04	13.87
Developing Country	6,801	156	8.82	5.05	13.87
Developing Countries	6,769	157	8.82	5.06	13.88