Global Human Microbiome Research: A Scientometric Analysis

Chikku Balachandran[1] and Khaiser Jahan Begum[2]
[1]Research Scholar, [2]Professor, [1&2]Department of Studies in Library and Information Science
Manasagangothri, University of Mysore, Karnataka, India
E-Mail: chikkubalachandran@gmail.com, khaiser.nikam6@gmail.com

Abstract - **The field of scientometrics is ever growing and helps in analyzing the science indicators such as research output in a subject, institutions and author productivity etc. Present study is about scientometrics of microbiome research literature. In this paper the authors have covered language, subject, country wise distribution of literature for ten years (2009 and 2018), taking the data from Web of Science. MS Excel is used for presentation and preparation of different tables. The year 2018 has highest no of publications. English language scores 98.78% in communicating microbiome research. Of the fifteen journals listed, 'PLOS ONE' ranks first. 'Microbiology' has maximum number of publications (25.04%). USA has contributed largest number of publications (46%). University of California Systems (6.8%) ranks first. Knight, R. is the most productive author (156 papers). Thus, scientometrics of microbiome research literature has shown interesting trends and has added to existing body of scientometric.**
Keywords: **Scientometric, Microbiome Research, Authorship Productivity, Journals Ranking, Subject/Language/Country Wise Distribution**

I. INTRODUCTION

The term "microbiome" refers to the diverse microorganisms present in living organisms (Hum, n.d.). They are mainly bacterial and play the vital role in the host body in various activities ranging from metabolism to immune system. They form the "first line defense against pathogens" (Body, n.d). Human microbiome research has gained much popularity in recent years mainly because of their influence with various lifestyle diseases like diabetics, obesity and some collection of microbes determines the drug treatment responds of each person. "A more complete understanding of the diversity of microbes in the human microbiome could lead to new therapies, perhaps treating a bacterial infection caused by "bad" bacteria by growing more "good" bacteria" (fast, n.d.).Scientometric study of human microbiome research is an attempt to find out the growth pattern of this research area over the time and productivity of various countries and institutions, authors etc.Scientometric study is a popular and useful research toolused to analyze the science communication indicators using various scientometric techniques.

II. RELATED LITERATURE

Review of related literature throws lights on the historical background and relevant theories and concepts related to the topic under research. It provides the necessary knowledge to fill the gaps remains in the research problem.

There are very few studiesconducted so far on the scientometric analysis of human microbiome. As most of the studies are restricted to intestinal microbiota and obesity, there isa need to study the global research trends in microbiome research, contribution of institutions, scientist and countries. For studies on scientometrics, certain resources of literature are needed for the collection of data and required material. The most common sources used nowadays are Web of Science, Scopus etc. In this study also the research literature in microbiome is gathered from Web of Science, the citation database by Clarivate Analytics formerly Thomson Reuters. It covers almost all domains of science and covers more than 10000 journals. Similar trend is noticed in the previously published research papers which are presented in the review of literature in the following paragraph.

Kaur and Gupta (2009) examined the research performance of India in terms of publication output in immunology and microbiology covering a period from 1999 to 2008 data. A total of 13172 research papers were found. The results show that India holds 12th position among the most productive institutions and witnessed 18.74% rise in international collaboration during 2006 to 2008. Dutt and Nikam (2013) examined global solar cell research using scientometric method and found USA leads the global solar cell research among the 14 countries followed by China is the next leading country. Tian *et al.,* (2016) conducted a bibliometric analysis of 100 most cited publications in microbiota of diabetes research using web of science database. From the results it was evident that USA and Belgium were the leading countries and the journal 'Diabetes' published the greatest number of articles. Ejtahed *et al.,* (2018) analyzed the world-wide trends in gut microbiota and obesity research publications using Scopus database. Out of 4384 documents retrieved the leading subject area was Medicine and the top productive country was USA. A similar study was conducted by Yao *et al.,* (2018) role of intestinal microbiota in obesity research trends and found out an exponential growth in publication numbers during the study period. PLOS ONE is the most productive journal and Europe and North America produced highest number of research articles.Similar study was carried out by Huang, Fan and Chen (2019) to find out the research foci in gastrointestinal microbiome and USA was the most productive country and University of North Carolina bagged the top rank among the most productive institution. Analysis of co word occurrences shows that gut microbiota and

related digestive diseases forms the hotspot in gastrointestinal microbiome research.

III. OBJECTIVES

The main objectives of the present study are
1. To study the growth of literature during the period 2009 – 2018
2. To find out the type of document and language of publications
3. To rank the journals in the field of microbiome research
4. To reveal the subject wise distribution of articles in microbiome research
5. To identify the geographical origin of literature in microbiome research
6. To identify the most prolific institutions in the field of microbiome research
7. To assess the most productive authors in microbiome research literature

IV. METHODOLOGY

In this study Web of Science database is used to retrieve all the literature published on 'human microbiome'covering a period of ten years from 2009 to 2018.All relevant articles in the field of microbiome are included in the analysis with no language limitation. All hyponyms of microbiome were used to extract the data such as'human microbiome', 'human microbiota', 'human microbes', 'human microflora', 'human microbial species. Publications in the field of fisheries, veterinary, forestry. Soil science, material science, chemistry, mathematics and computer science etc. are excluded. The references and bibliographical information collected were exported to MS Excel for the analysis of year wise publication, geographical origin of literature, prolific authors, most prolific organization and funding agencies etc.

V. RESULTS AND DISCUSSIONS

The results, discussion and the interpretation of scientific research productivity in the field of human microbiome research are arranged in the following tables with titles

1. Year wise Distribution of research literature
2. Type of Documents
3. Ranking of journal publication in microbiome research
4. Research areas in Microbiome research
5. Geographic origin of Microbiome research literature
6. Ranking of most productive institutions
7. Ranking of most productive authors in microbiome research literature

A. Year wise Distribution of Microbiome research literature

Year-wise growth of publications in human microbiome research during the study period 2009 to 2018 is shown in Table-I. It is evident that microbiome research is in a state of steady growth over the years. Out of 12369 records the maximum number of publications 2248 (18.47%) is published in the year 2018 followed by 2130 publications

(17.22%) in the year 2017, 1741 publications in the year 2016 and so on. In the 2009 the literature production was less during the study period.ie, 429(3.47%)

TABLE I YEAR WISE DISTRIBUTION OF MICROBIOME RESEARCH LITERATURE

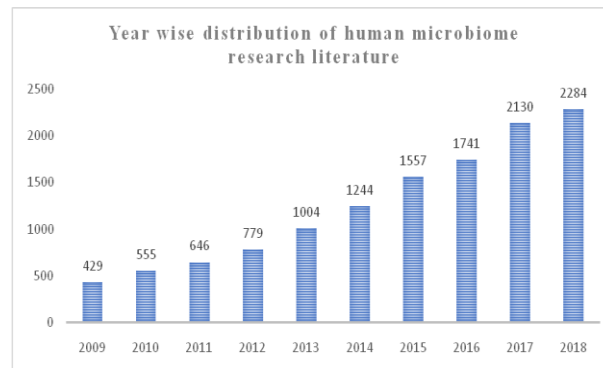| S. No.	Publication Year	No. of Publications	Percentage
1	2009	429	3.47
2	2010	555	4.49
3	2011	646	5.22
4	2012	779	6.28
5	2013	1004	8.12
6	2014	1244	10.06
7	2015	1557	12.59
8	2016	1741	14.08
9	2017	2130	17.22
10	2018	2284	18.47

Fig. 1 Year wise Distribution of Microbiome research literature

B. Type of Documents

Document wise distribution of publications in the field of the human microbiome research is displayed in Table II. It can be observed that 97.89% (12109) out of total number of data i.e., 12369 are in the form of research articles. Proceedings papers, book chapters, data papers and others together constitute below 3% (260) of the total data.

TABLE II TYPE OF DOCUMENTS

S. No.	Document Type	No. of Publications	Percentage
1	Article	12109	97.89
2	Proceedings paper	125	1.032
3	Book chapter	48	0.396
4	Data paper	28	0.231
5	Others	59	0.47
	Total	12369	100

C. Language of Publication

Different languages in which the scientists publish across the globe in the field of microbiome is listed in Table III.

TABLE III LANGUAGE OF PUBLICATION

S. No.	Language	No. of Publications	Percentage
1	English	12219	98.787
2	German	37	0.299
3	Polish	35	0.283
4	French	26	0.21
5	Spanish	20	0.162
6	Russian	12	0.097
7	Korean	5	0.04
8	Italian	3	0.024
9	Japanese	3	0.024
10	Hungarian	2	0.016
11	Czech	1	0.008
12	Greek	1	0.008
13	Icelandic	1	0.008
14	Norwegian	1	0.008
15	Slovenian	1	0.008
16	Turkish	1	0.008
17	Ukrainian	1	0.008

Total 17 languages were identified in which English is the most preferred language for research publication with 98.78% (12219) followed by German (37; 0.299%), Polish (35; 0.283%), French (26; 0.21%), Spanish (20; 0.162%) and Russian with 12 (0.097%) is the 5th position. The remaining 20(0.162%) research papers are in other languages such as Korean, Italian, and Japanese etc.

D. Ranking of Journal Publications in Microbiome Research

The publication on Microbiome research were spread over 2194 journals. Table IV shows the 15 top most ranked journals in the field of microbiome research. The leading journal preferred by the scientists was PLOS ONE with 642 (5.19%) publications followed by Frontiers in Microbiology (384; 3.11%) publications and Scientific Reporters (226; 2.19%) respectively.

E. Research Areas in Microbiome Literature

Distribution of research areas of Human Microbiome is displayed in Table V. Total 14 relevant research areas have been identified and there are other research areas forms 75% of research literature.

TABLE IV RANKING OF JOURNAL PUBLICATIONS IN MICROBIOME RESEARCH

S. No.	Journal/Proceeding Title	No. of Publications	Percentage
1	PLOS ONE	642	5.19
2	Frontiers in Microbiology	384	3.105
3	Scientific Reports	271	2.191
4	Microbiome	226	1.827
5	MBIO	161	1.302
6	Proceedings of the National Academy of Sciences of the United States of America	161	1.302
7	Applied and Environmental Microbiology	140	1.132
8	Frontiers in Immunology	126	1.019
9	ISMEJournal	105	0.849
10	M Systems	92	0.744
11	Journal of Immunology	90	0.728
12	Cell Host Microbe	87	0.703
13	Nature	83	0.671
14	Gastroenterology	76	0.614
15	BMCMicrobiology	73	0.59

It is observed that the publication is Microbiology subject area has maximum research literature with 3192 i.e., 25% of total publications.

This is followed by science technology and other topics (1493; 12.07), Immunology (1281; 10.36%), Biochemistry molecular biology (1159; 9.97%). The fifth place is claimed by Biotechnology and applied microbiology with 930(7.52%) publications.

F. Geographic Origin of Microbiome Literature

A total 123 countries were represented across the globe in human microbiome research during the study period. The top 10 productive countries in the microbiome research area are indicated in Table VI and Fig. 2. USA has produced the highest number of publications with 3915 (46%) records followed by China with 806 (8.19%) publications, England with 793 (7.37) publications and so on.

TABLE V RESEARCH AREAS IN MICROBIOME LITERATURE

S. No.	Research area	No. of Publications	Percentage
1	Microbiology	3192	25.80
2	Science technology other topics	1493	12.07
3	Immunology	1281	10.36
4	Biochemistry molecular biology	1159	9.37
5	Biotechnology applied microbiology	930	7.52
6	Gastroenterology hepatology	747	6.04
7	Nutrition dietetics	629	5.09
8	Cell biology	541	4.37
9	Pharmacology pharmacy	527	4.26
10	Research experimental medicine	492	3.98
11	Genetics heredity	486	3.93
12	Environmental sciences ecology	475	3.84
13	Infectious diseases	455	3.68
14	Food science technology	453	3.66
15	Endocrinology metabolism	299	2.42

TABLE VI GEOGRAPHIC ORIGIN OF MICROBIOME LITERATURE

| S. No.	Country	No. of Publications	Percentage
1	USA	5704	46.115
2	Peoples r china	1013	8.19
3	England	912	7.373
4	Germany	877	7.09
5	Canada	704	5.692
6	France	633	5.118
7	Italy	575	4.649
8	Netherlands	540	4.366
9	Australia	475	3.84
10	Japan	444	3.59
11	India	430	3.476
12	Spain	396	3.202
13	Sweden	372	3.008
14	Switzerland	287	2.32
15	Denmark	285	2.304
16	Belgium	264	2.134
17	Finland	261	2.11
18	South Korea	247	1.997
19	Ireland	240	1.94
20	Brazil	210	1.698
21	Poland	195	1.577
22	Scotland	172	1.391
23	Austria	164	1.326
24	Israel	145	1.172
25	Norway	138	1.116
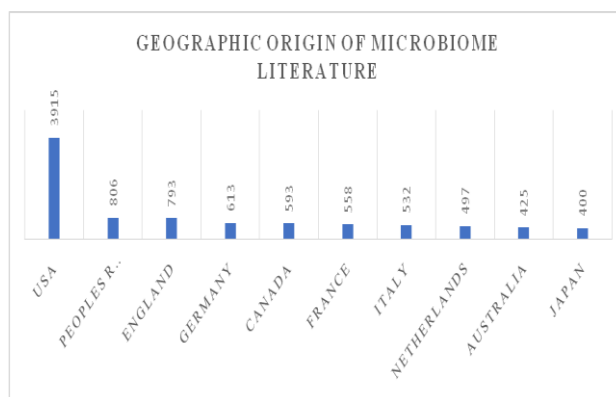
Fig. 2 Geographic Origin of Microbiome Literature

G. Ranking of Most Productive Institutions

The top 25 prolific institutions involved in the human microbiome contributing at least 1% of the total research literature is presented in Table VII. The most productive research institutions were University of California System with 842 (6.81%) publications followed by Harvard University with 555 (4.49%) and so on as per the web of science data.

H. Ranking of Most Productive Authors in Microbiome Research

The list of the top 10 most productive authors in microbiome research is given in Table VIII. Knight R with 156(1.27%) publications tops the list followed by De Vos WM with 82(0.66%) publications, Huttenhower C with 71(0.57%) publications, Wang J 55(o.45%) publications and Dore J with 49 (0.34%) publications in the 5th position. The remaining 10 authors in the table together constitute the 3.5% of the total publications.

TABLE VII RANKING OF MOST PRODUCTIVE INSTITUTIONS

S. No.	Name of Institution	No. of Publications	Percentage
1	University of California System	842	6.807
2	Harvard University	555	4.487
3	Va Boston Healthcare System	314	2.539
4	University of California San Diego	262	2.118
5	Centre National De La Recherche ScientifiqueCnrs	252	2.037
6	National Institutes of Health NIH USA	242	1.957
7	University of Colorado System	226	1.827
8	University of London	223	1.803
9	University of North Carolina	223	1.803
10	United States Department of Energy Doe	218	1.762
11	Institute National De La Sante Et De La Recherche MedicaleInserm	214	1.731
12	Massachusetts Institute Of Technology MIT	195	1.577
13	Institute National De La Recherche Agronomique INRA	187	1.512
14	Washington University WUSTL	185	1.496
15	Wageningen University Research	180	1.455
16	University of Copenhagen	178	1.439
17	University of Michigan	173	1.399
18	University of Michigan System	173	1.399
19	University of Illinois System	171	1.382
20	University of California San Francisco	170	1.374
21	University of Texas System	166	1.342
22	University of Chicago	165	1.334
23	Pennsylvania Commonwealth System of Higher Education Pcshe	163	1.318
24	Chinese Academy of Sciences	161	1.302
25	University of California Davis	161	1.302

TABLE 8 RANKING OF MOST PRODUCTIVE AUTHORS IN MICROBIOME RESEARCH

Rank	Author	No. of Publications	Percentage
1	Knight R	156	1.261
2	De Vos W M	82	0.663
3	Huttenhower C	71	0.574
4	Wang J	55	0.445
5	Dore J	49	0.396
6	Paster BJ	47	0.38
7	Gordon J I	46	0.372
8	Raoult D	46	0.372
9	Chen J	44	0.356
10	Li J	44	0.356
11	Ravel J	43	0.348
12	Blaser M J	41	0.331
13	Versalovic J	41	0.331
14	Knights D	40	0.323
15	Li Y	40	0.323

VI. SUMMARY

1. It is evident that97.13% (12109) of data of 12369 publications, are in the form of research articles.
2. Out of 17 languages identified, English is the most preferred language for scientists for research publication with 98.78% (12219) articles.
3. It can be inferred from the data that microbiome research is in a steady state of growth over the ten years. Out of 12369 records the maximum number of publications 2248 (18.47%) are in the year 2018.
4. 'Knight R' is the most productive author with 156 publications followed by 'De Vos WM'with 82 publications.
5. Total 14 research areas have been identified and Microbiology is the most active research area in microbiome research with 25% of total articles.
6. The leading journal preferred by the scientists was PLOS ONEcontributing 642 (5.19%) research papers followed by Frontiers in Microbiology with 384 (3.11%) publications.
7. A total 123 countries were represented across the globe in Human microbiome research during the study period

and USA is the top most productive country with 3915 research contributions.

8. The most productive research institutions were University of California System (842; 6.81%) publications followed by Harvard University (555; 4.49%) and so on as per the web of science data.

VII. CONCLUSION

The field of scientometrics is forever growing and is enriched in supporting the development of science and its growth in different area. The basis for the emergence of scientometrics is no doubt bibliometrics, but together these two facets of measuring scientific contributions have given room for the growth of related and innovative concepts in measuring the research output both locally and globally. The other domains of scientometrics are informetrics, webometrics, link analysis, citation measurement and author networking. Application of scientometrics to the field of science such as microbiome research has helped the authors in identifying the nature and characteristics of microbiome research literature. In this paper the authors have covered language, subject, country wise distribution of literature during 2009 and 2018. The obvious source of gathering the data has been Web of Science, which facilitates in retrieving relevant research materials for the purpose of scientometric analysis. The scientometric method is supported by many other tools like MS Excel, Bibexcel etc. Here MS Excel is extensively used for presentation and preparation of different tables required for the study. The list of journal publications is limited to fifteen.

The study indicates that 2018 has a greater number of publications. English is the predominant language of microbiome research communications, scoring 98.78%. PLOS ONE tops among the several journals listed. The subject microbiology has produced maximum number of publications (25.04%). USA has produced largest number of publications in microbiome research, scoring 46%. University of California Systems (6.8%) tops first, followed by Harvard University (4.48%) and VA Boston Healthcare systems (2.54%) in the same order. Knight, R. is the most productive author (156 papers) followed by De Voss, W. M. (82 papers) and Huttenhower, C. (71 papers). Thus, the research carried on scientometrics of microbiome has shown interesting trends and the paper has contribute to the existing body of scientometric research.

REFERENCES

[1] Human microbiome. (n.d). Retrieved from http://www.britannica.com/science/human-microbiome.

[2] The Body's Ecosystem. (n.d.). Retrieved from http://www.the-scientist.com/features/the-bodys-ecosystem-37085

[3] Fast Facts About the Human Microbiome - UW Departments Web ... (n.d.). Retrieved from https://depts. washington .edu/ceeh/downloads/FF_Microbiome.pdf.

[4] Kaur, H., & Gupta, B.M. (2009). Indian Contribution in Immunology and Microbiology1999-2008: A Scientometric Analysis. *DESIDOC Journal of Library & Information Technology, 29*(5), 36-43.

[5] Dutt, B., & Nikam, K. (2016). Scientometric analysis of global solar cell research. *Annals of Library and Information Studies, 63*(2016), 31–41.

[6] Tian, J., Li, M., Lian, F., & Tong, X. (2017). The hundred most-cited publications in microbiota of diabetes research. *Medicine*, *96*(37), 1-7.

[7] Ejtahed, HS *et al.,* Worldwide trends in scientific publications on association of gut microbiota with obesity. *Iran J Basic Med Sci*, *22*, 65-71. https:// doi:10.22038/ijbms.2018.30203.7281

[8] Yao *et al.,* (2018), Bibliometric analysis of research on the role of intestinal microbiota in obesity. PeerJ 6:e5091; https://doi.org/ 10.7717/peerj.5091

[9] Huang, X., Fan, X., Ying, J., & Chen, S. (2019). Emerging trends and research foci in gastrointestinal microbiome. *Journal of Translational Medicine*, *17*(67), 1–11. https://doi.org/10.1186/s12967-019-1810-x

[10] Pasternak, S., & Khlebobpros, R. (2017). Scientometric Analysis of Human Microbiome Project. *Journal of Siberian Federal University. Humanities & Social Sciences, 7*(10), 1076-1082. DOI: 10.17516/1997-1370-0116

[11] Das, B., Ghosh, T. S., Kedia, S., Rampal, R., & Saxena, S. (2018). Analysis of the Gut Microbiome of Rural and Urban Healthy Indians Living in Sea Level and High-Altitude Areas. *Scientific Reports*, (June 2017), 1–15. https://doi.org/10.1038/s41598-018-28550-3

[12] The Human Microbiome. (n.d.). Center for Ecogenetics & Environmental Health. Retrieved from https://depts.washington.edu/ ceeh/downloads/ FF_Microbiome.pdf