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A BIBLIOMETRIC ANALYSIS OF GLOBAL RESEARCH OUTPUTS ON SEAFOOD AND ANTIBIOTICS (1999 – 2019)

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Abstract: *This study is aimed at investigating the global trend in research activities involving seafood and antibiotics based on published research output articles. Peer reviewed articles published in the last two decades involving seafood and antibiotics were searched on the Scopus database using the search words "seafood" and "antibiotics''. The retrieved data were then analyzed based on the total research outputs, countries and affiliation of authors, sources of funding, keywords used by the authors, citations and collaborations using both add-on analytical tool, Microsoft Excel and VOS viewer for data visualization. A total of 447 research outputs by 710 authors affiliated with 1173 institutions from 74 countries using 1051 keywords were obtained. Original research articles accounted for the highest percentage (87.7%) and published across 166 different peer-reviewed journals. Most of the original research articles were published in the International Journal of Food Microbiology 27(16.3%). Khan, A. A. from the Division of Microbiology; National Centre for Toxicological Research, United States, was the most productive author with 10 (2.2%) publications while the National Natural Science Foundation of China was the highest funding institution with 22 (4.9%) and the United States of America was the most productive with 91 (20.4%) research outputs followed by China with 70 (15.7%) research outputs. Over the last two decades (1999 – 2019), there has been an exponential (r^2=0.91) increase in seafood and antibiotics related research activities. The majority of these research activities were from America, Asia and Europe. There is need for international scientific collaboration between the leading researchers and researchers from developing countries in seafood research to help mitigate food loss, enhance food security, and increase the productivity of early career researchers.*

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Key words: *seafood, antibiotics, shelf-life, aquaculture, microbial community.*

1. Introduction

Worldwide fish production reached 177.8 million tons in 2019. Most fish and fishery products (158.2 million tons) are used for human consumption, while the rest is for other purposes (19.6 million tons). The aquaculture sector contributes to sustainable production and in 2019 production increased by 3.9% as compared to 2018. Fish consumption per capita has also increased in recent years reaching 20.5 kg/year in 2019 [14].

Consumption of contaminated seafood causes diseases in humans such as acute infections with bacterial, viral and parasitic agents, acute intoxications with biotoxins and chronic exposure to chemical contaminants, including antibiotics used in aquaculture [25]. Antibiotics are widely used for the prevention and treatment of bacterial diseases in humans and animals. In addition, they are added to feed as aquaculture growth stimulators. Due to these reasons, water in which aquaculture is grown may contain high concentrations of antibiotics [19]. In the USA, Canada, and Europe, only a relatively small number of antibiotics are permissible for use in aquaculture. These include erythromycin, amoxicillin, florfenicol, oxytetracycline, oxolinic acid, flumequine, sulfadimethoxine / ormetoprim, sulfadiazine / trimetoprim [24]. In recent years, great attention has been paid to antibiotics in water ecosystems due to their harmful effect on the organisms in them. Antibiotics can both reduce microbial diversity and modify bacterial ecology in water. Misuse can also increase the occurrence in aqueous environments of genes coding resistance to antibiotics [40]. The main issue in the large-scale use of antibiotics is the development of resistant bacteria in water and fish [19], [24] and consequent negative effects on the consumer's health.

The bibliometric analysis provides a statistical and visible approach to tendencies, models and predilections trends in academic research work. Moreover, it gives an overview of the scientific production of a specific academic subject. Bibliometric analysis has preferences such as visualization, quantification and knowledge discovery [6]. There is dearth of information regarding the trend of research outputs on seafood and antibiotics. Therefore, this study aims to investigate the global trend in the research activities involving seafood and antibiotics based on published research output articles.

2. Materials and Methods

Scopus database was used in this study because it houses more than 30000 scientific literature items (journals, books and conference proceedings) in subject areas such as sciences, medicine, humanities and social sciences more than Web of Science [26]. The database also contains over 20000 journal titles from more than 5000 publishers [43]. The database also has inbuilt analytical tools that can be used to analyse citation, views etc. [1].

The authors firstly agreed on the search

words to use. The search words used were “seafood and antibiotics”. The first keyword (seafood) was quoted as “seafood”. This was to prevent false positive search results. A Boolean operator “AND” was also used to link the two keywords together ensuring that only studies relating to seafood and antibiotics were retrieved.

1. The search was limited to scientific publications in the past twenty years (1999 – 2019). All types of research outputs published in English were considered;
2. The above steps yielded the search query string below:

TITLE-ABS-KEY ("seafood" AND antibiotics) AND (LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010) OR LIMIT-TO (PUBYEAR, 2009) OR LIMIT-TO (PUBYEAR, 2008) OR LIMIT-TO (PUBYEAR, 2007) OR LIMIT-TO (PUBYEAR, 2006) OR LIMIT-TO (PUBYEAR, 2005) OR LIMIT-TO (PUBYEAR, 2004) OR LIMIT-TO (PUBYEAR, 2003) OR LIMIT-TO (PUBYEAR, 2002) OR LIMIT-TO (PUBYEAR, 2001) OR LIMIT-TO (PUBYEAR, 2000) OR LIMIT-TO (PUBYEAR, 1999)) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re") OR LIMIT-TO (DOCTYPE, "le") OR LIMIT-TO (DOCTYPE, "ch") OR LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "bk")) AND (LIMIT-TO (EXACTKEYWORD, "Seafood") OR LIMIT-TO (EXACTKEYWORD, "Sea Food") OR LIMIT-TO (EXACTKEYWORD, "Antibiotic Resistance")) AND (LIMIT-TO (LANGUAGE, "English") OR LIMIT-TO (LANGUAGE, "Chinese") OR LIMIT-TO (LANGUAGE, "Korean") OR LIMIT-TO (LANGUAGE, "German") OR LIMIT-TO (LANGUAGE, "Japanese") OR LIMIT-TO (LANGUAGE, "French") OR LIMIT-TO (LANGUAGE, "Spanish") OR LIMIT-TO (LANGUAGE, "Turkish") OR LIMIT-TO (LANGUAGE, "Italian") OR LIMIT-TO (LANGUAGE, "Russian")) AND (LIMIT-TO (SRCTYPE, "j") OR LIMIT-TO (SRCTYPE, "b") OR LIMIT-TO (SRCTYPE, "k") OR LIMIT-TO (SRCTYPE, "p")).

The results obtained were then exported as a comma-separated values (CSV) file with the inclusion of “Citation information”, “Bibliographical information”, “Abstract and keywords, “Funding details” and “References.” From the add-on analytical tool, the ten most productive journals, ten most productive scientists, countries, funding sources and the most cited research outputs (journal articles) were retrieved.

1. Network visualization of co-citation, co-authorship, and the keywords of the retrieved data was carried out using VOSviewer version 1.6.11 [41] as described by Ale Ebrahim et al. [3]:
   a) Visualisation of co-authorship using authors as unit of analysis and full counting method. 2050 authors, 1000 authors were selected by default;
   b) Visualisation of co-occurrence using authors’ keywords 1051 keywords, 1000 keywords were selected by default;
   c) Visualisation of citations using articles;

d) Visualisation of citations using countries of 74 countries with at least three countries;
e) Visualisation of citations based on 1173 affiliations at least 2 affiliations;

2.The following bibliometric indicators of research productivity were also investigated:
a) Productivity growth based on Price's law of exponential growth [23], [29]. The data on the total number of research outputs versus years of publications was linearly and exponentially fitted. This law was said to be fulfilled if the coefficient of regression (r^2) of the exponential curve is greater than that of the linear curve;
b) **Impact factor:** The journal's impact factor determines the number of times that articles in a journal were cited in a year by the articles published in that journal over a period of two preceding years was obtained from the journal website as calculated by means of the Journal Citation Report [23];
c) **Participation index,** which indicates the level of research performance of an institution or country in a research field (in this case seafood and antibiotics). This was expressed as the number of publications from a country or institution against the total number of publications reported in this study multiplied by 100 [23].

3. Results

The results of the bibliometric analysis of the global research output on seafood and antibiotics for two decades from 1999-2019 on articles indexed in Scopus was carried out based on the annual growth of articles, the analysis of participating journals, authors, affiliations of the authors, funding bodies or sponsors, the analysis of outputs of documents types, subject area, countries, citation analysis and keywords or terms used by authors.

3.1. Quantity and Growth of Research Output

There was an obvious exponential growth (r^2=0.91) in research outputs in the last twenty years (1999-2019) involving seafood and antibiotics. A total of 447 research outputs were obtained using seafood and antibiotics as keywords. A marginal increase in the number of publications was observed between 1999 and 2008. After 2008, the rise in the number of publications was noticeable. The highest research output was observed in 2019 with 71 publications and the least was in 1999 (Figure 1). The average numbers of research outputs per year was 21.3 and a compound growth rate of 16.3% was observed.

3.2. Types of Documents Retrieved

Among the 447 research outputs obtained in this study, original research articles accounted for the highest percentage (87.7%) of documents retrieved (392/447). This was followed by review papers 9.2% (41/447) and the least encountered document type was

conference paper 0.2% (1/447) as indicated in Figure 2. All retrieved documents were final and published papers.

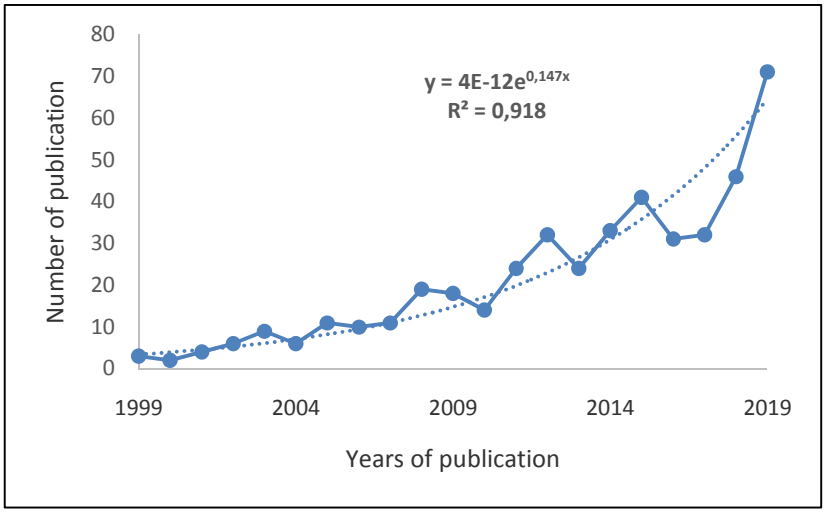

Fig. 1. *The number of research output in two decades (1999-2019)*

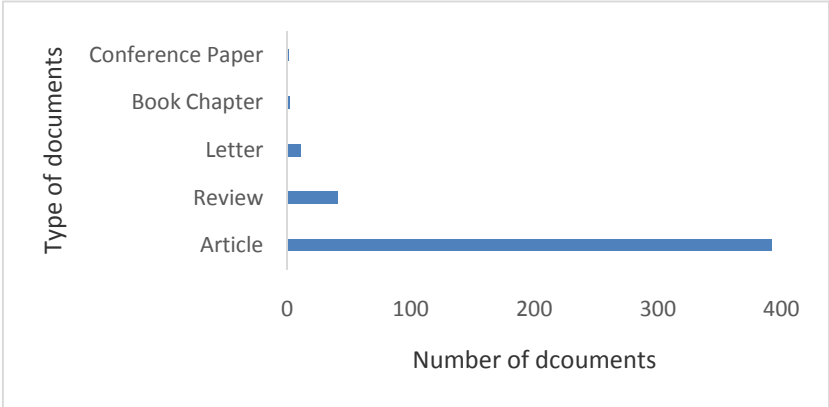

Fig. 2. *Distribution of retrieved documents according to types*

3.3. Authors' Preferred Journals and Subject Areas

The retrieved 447 documents were published across 166 different peer-reviewed journals by 710 authors within the last two decades. As shown in Figure 3, the 10 top most preferred journals for publishing in ascending order were International Journal of Food Microbiology 27(16.3%), Journal of Food Protection 15(9.0%), Food Microbiology 14(8.4%), Frontiers In Microbiology 13(7.8%), Journal of Applied Microbiology 12(7.2%), Foodborne Pathogens and Disease 11(6.6%), Marine Pollution Bulletin 11(6.6%), Applied and Environmental Microbiology 9(5.4%), Antimicrobial agents And Chemotherapy 8(4.8%) and Food Additives and Contaminants Part A

Chemistry Analysis Control Exposure and Risk Assessment 8(4.8%). The top 13 subject areas indicated that most researches were based on Immunology and Microbiology 186 (41.6%) followed by Medicine 176 (39.4%), Agricultural and Biological Sciences 158 (35.3%) and the least of the top 13 was Veterinary 3 (0.7%) (Figure 4).

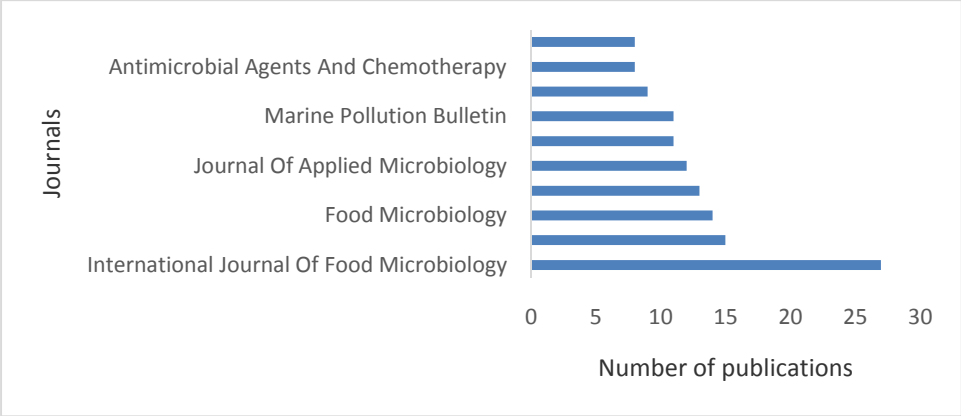

Fig. 3. *Analysis of authors' preferred journals*

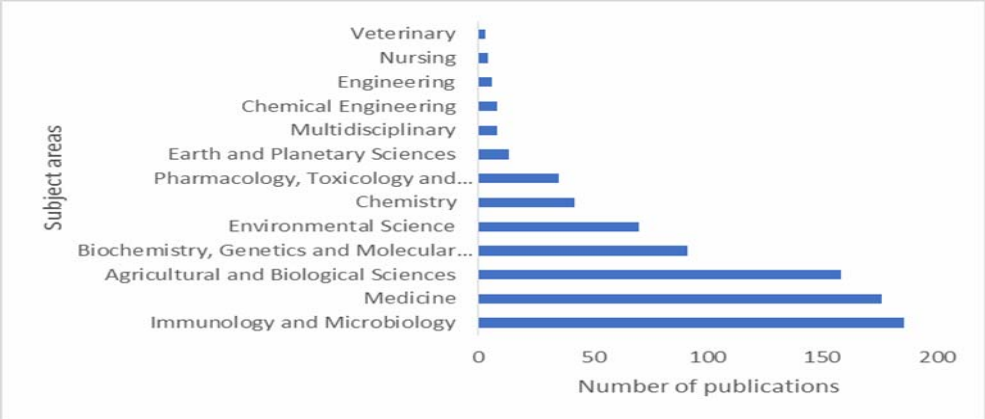

Fig. 4. *Subject area analysis of research output from 1999 – 2019*

3.4. Analysis of the Ten Most Active Authors

In the period surveyed, 2050 authors were involved in the publication of 447 retrieved papers with a mean of 1.6 authors per published paper. The top ten authors in the last two decades who published research on seafood and antibiotics contributed 12.3% of the total publications. Khan, A. A. from the Division of Microbiology; National Centre for Toxicological Research, United States [22], was the most productive author with the highest publication rate of 10 (2.2%), followed by Shi, L. 6 (1.3%) (Figure 5).

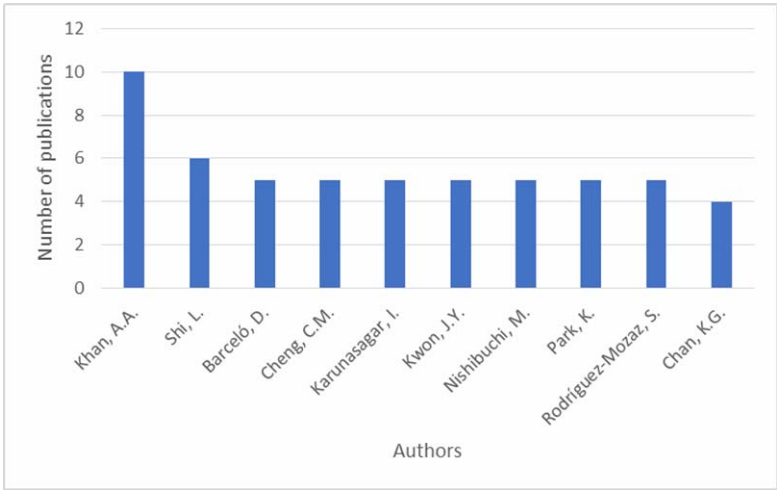

Fig. 5. *Top ten researchers in seafood and antibiotics (1999–2019)*

3.5. The Most Productive Institutions

The documents retrieved were affiliated to a total of 1173 institutions from 74 countries representing an average of 2.6 institutions per document. National Centre for Toxicological Research was the most active institution in research on seafood and antibiotics with a total of 12 (2.7%) publications followed closely by the Ministry of Agriculture of the People's Republic of China and Shanghai Ocean University with 9 (2.0%) research outputs each. The National Fisheries Research and Development Institute (NFRDI) had 8 (1.8%) publications. Among the ten top productive institutions there are Zhejiang University, University of Guelph, South China University of Technology, Cochin University of Science and Technology, and University Putra Malaysia were the least productive with 7 (1.6%) publications each (Figure 6).

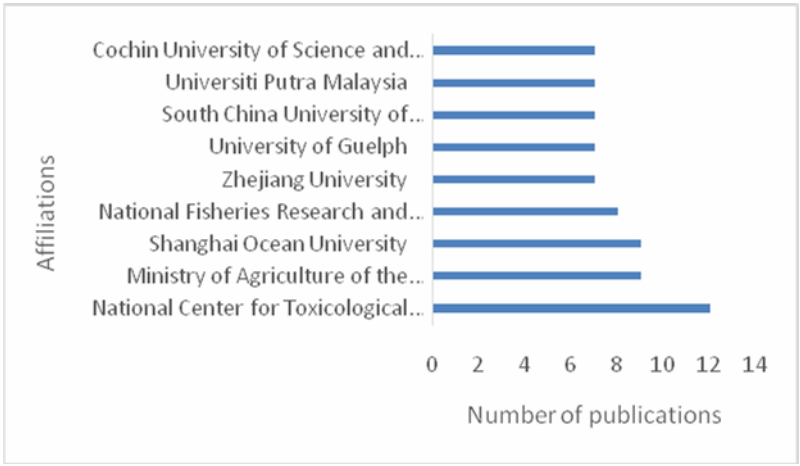

Fig. 6. *Research productivity by authors' affiliations from 1999 – 2019*

3.6. Analysis of Funding Institutions

The analysis of research funding institutions indicated that the National Natural Science Foundation of China was the highest funding institution with 22 (4.9%) out of the 447 retrieved publication funded by the institution. Among the top 10 funding institutions there were the European Commission and the European Regional Development Fund were second with 6 (1.3%) each, followed by the Ministry of Education, Culture, Sports, Science and Technology and National Research Foundation of Korea with 5 (1.1%) each. Others were Fundamental Research Funds for the Central Universities and the National Basic Research Program of China (973 Program) with 4 (0.9%) research outputs each. The least of the top 10 funding institutions had 3 (0.7%) research outputs each (Figure 7).

3.7. The Most Productive Countries

Among the 74 countries that were involved in the research on seafood and antibiotics within the study period (1999-2019), the United States of America was the most productive country with 91 research outputs and a participation index of 20.4%. This was followed by China with 70 (15.7%) research documents. Included in the ten most active countries were India 41 (9.2%), South Korea 35 (7.8%), Japan and Spain 31 (6.9%) each, Canada 21 (4.7%), Italy 20 (4.5%). The United Kingdom was ranked the 10th most active country with 16 outputs (3.6%) (Figure 8). The geographical distribution of retrieved documents, according to country affiliation of authors, showed that the majority of the publications were from North America closely followed by Asia (Figure 9).

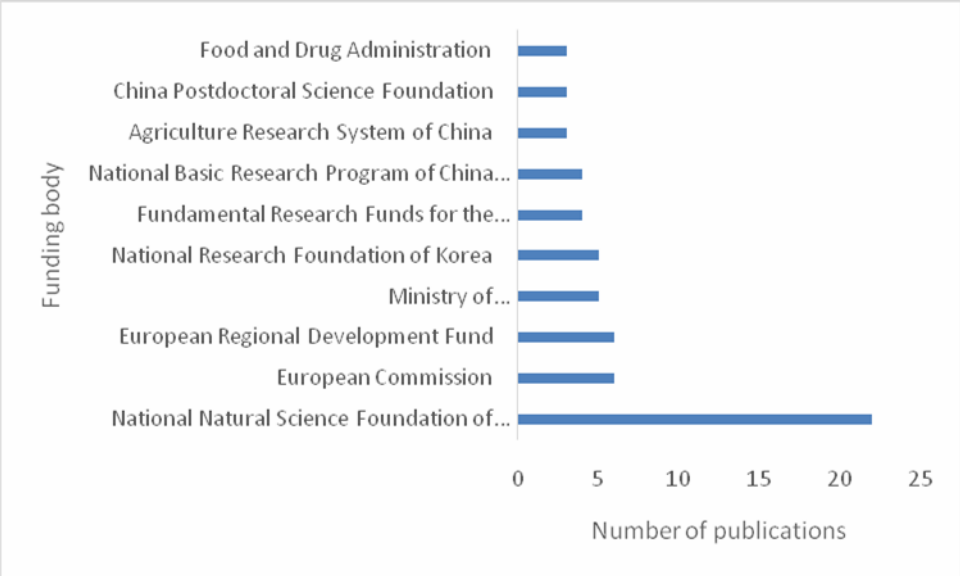

Fig. 7. *Analysis of top ten funding institutions in seafood and antibiotics research*

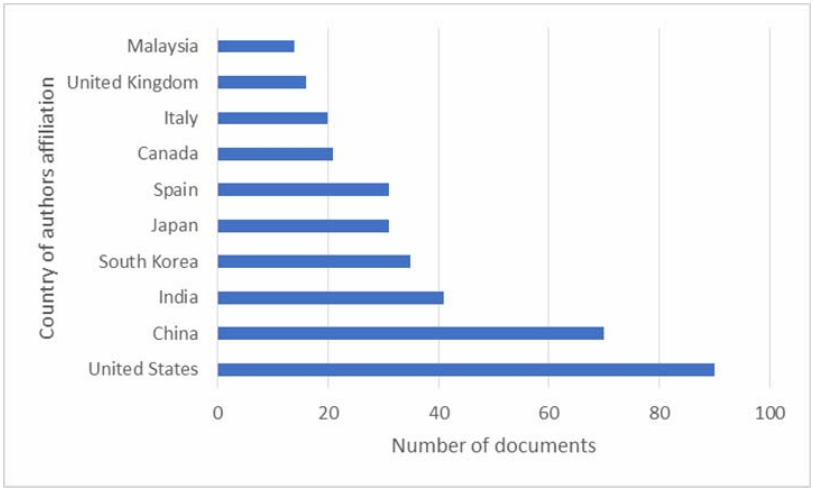

Fig. 8. *Ten most productive countries*

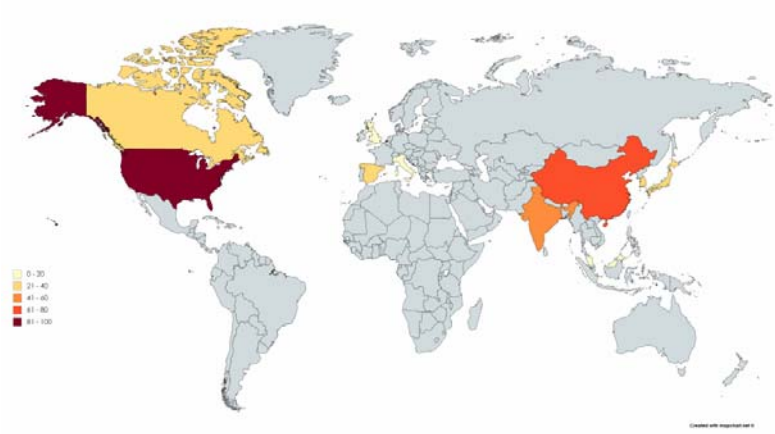

Fig. 9. *The geographical distribution of retrieved documents*

3.8. Citation Analysis

Citation analysis was carried out based on the most cited author, top ten most cited authors, top ten most cited documents, top ten most cited journals, and top ten most cited countries. Of the 2050 authors, Khan, A. A. was the most cited author with 10 publications and 304 citations, followed by Shi, L. with 191 citations and Li, L. with 164 citations (Table 1). Out of the ten most cited documents, Guerrant [17] was highest with 736 citations followed by Sapkota [32] with 410 citations. The lowest number of citations was recorded by Mottier [27] with 120 citations (Table 2). The most cited journal was the International Journal of Food Microbiology with 964 citations followed by Food Microbiology and Applied and Environmental Microbiology with 553 and 371 citations, respectively (Table 3). Of the seventy-four countries observed, USA was the most cited with 4256 citations followed by China with 1101 citations. India was the tenth of the most cited countries with 406 citations (Table 4).

Table 1

Ten most cited authors

S/N	Authors	No. of documents	No. of citations
1	Khan A.A.	10	304
2	Shi L.	6	191
3	Li L.	5	164
4	Barcelo D.	5	147
5	Rodriguez-Mozaz S.	5	147
6	Cheng C.M.	5	144
7	Nishibuchi M.	5	69
8	Wang X.	5	69
9	Karunasagar I.	5	62
10	Chen S.	6	61

Table 3

Ten most cited journals

S/N	Journals	No. of documents	Citations	Impact factor
1	International Journal of Food Microbiology	27	964	4.187
2	Clinical Infectious Disease	3	829	8.313
3	Food Microbiology	14	553	4.155
4	Environment International	3	431	7.577
5	Applied and Environmental Microbiology	9	371	4.016
6	Journal of Applied Microbiology	12	355	3.066
7	Marine Pollution Bulletin	11	278	4.049
8	Frontiers in Microbiology	13	238	4.076
9	Epidemiology and Infection	2	230	2.010
10	Journal of Animal Science	1	205	2.092

Table 4

Ten most cited countries

S/N	Country	No. of documents	Citations
1	USA	91	4256
2	China	21	1101
3	Canada	70	963
4	Spain	31	915
5	Georgia	2	738
6	Italy	20	607
7	Japan	31	573
8	Australia	11	544
9	South Korea	35	504
10	India	41	406

Table 2

Ten most cited documents

S/N	Author(s)	Titles	Journals	No. of citations
1	Guerrant et al. [17]	Practice guidelines for the management of infectious diarrheal	Clinical Infectious Diseases	736
2	Sapkota et al. [32]	Aquaculture practices and potential human health risks: Current knowledge and future priorities	Environment International	410
3	Oliver [30]	Wound infections caused by *Vibrio vulnificus* and other marine bacteria	Epidemiology and Infection	209
4	Foley and Lynne [15]	Food animal-associated *Salmonella* challenges: pathogenicity and antimicrobial resistance	Journal of animal science	205
5	Akinbowale et al. [2]	Antimicrobial resistance in bacteria isolated from aquaculture sources in Australia	Journal of Applied Microbiology	197
6	Cunningham et al. [8]	Human health risk assessment from the presence of human pharmaceuticals in the aquatic environment	Regulatory Toxicology and Pharmacology	172
7	Smit et al. [34]	Anaphylaxis presentations to an emergency department in Hong Kong: Incidence and predictors of biphasic reactions	Journal of Emergency Medicine	150
8	Butt et al. [5]	Infections related to the ingestion of seafood Part I: Viral and bacterial infections	Lancet Infectious Diseases	132
9	Goh et al. [16]	Early diagnosis of necrotizing fasciitis	British Journal of Surgery	130
10	Mottier et al. [27]	Determination of the antibiotic chloramphenicol in meat and seafood products by liquid chromatography-electrospray ionization tandem mass spectrometry	Journal of Chromatography A	120

3.9. Network Visualisation of Co-Authorship, Co-Citation, and Co-Occurrence of Authors Keywords

A total of 2050 authors were involved in the evaluated publications. However, only 1000 authors were selected by default for the visualisation (Figure 10a). The authors used 1051 keywords out of which 37 keywords occurred more than 5 times. Seafood and antibiotic resistance topped the list of occurrences of authors' keywords with 58 occurrences each followed by *Vibrio parahaemolyticus* with 42 occurrences. The list of top co-occurrences of authors' keywords was presented in Figure 10b.

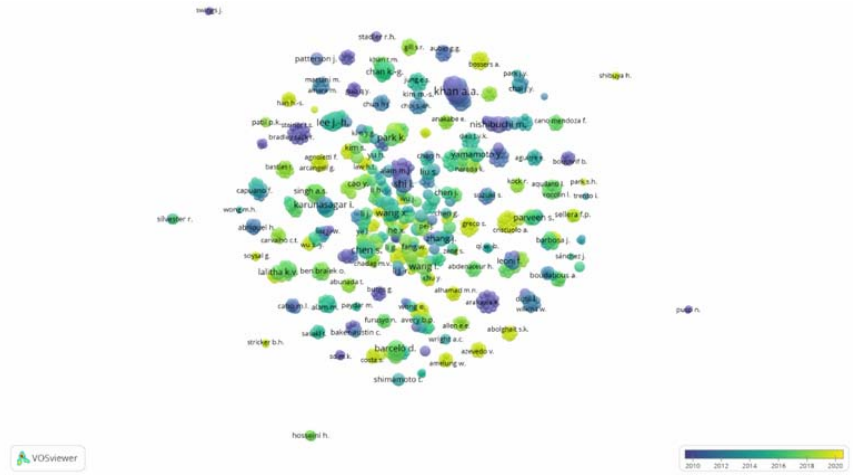

Fig. 10a. *Visualisation of co-authorship using authors as unit of analysis and the full counting method*

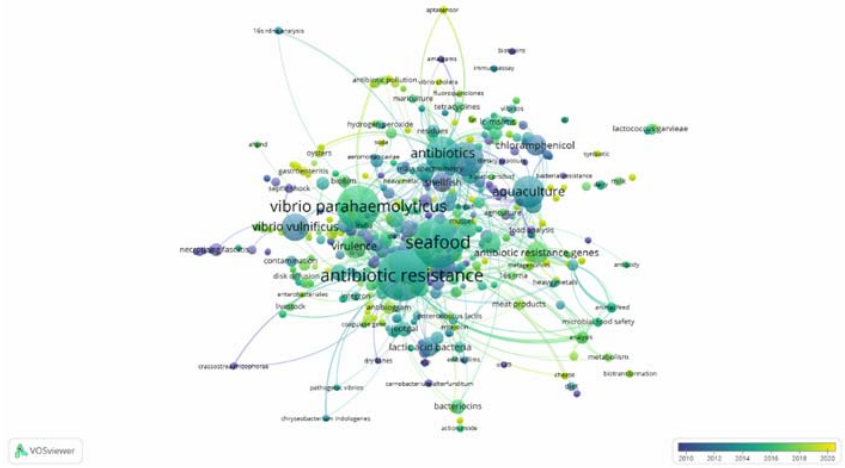

Fig. 10b. *Visualisation of co-occurrence using authors' keywords, 1000 keywords were selected by default. The trend of the use of keywords are shown by the colour of the bubbles*

The size of the bubble indicates the number of times that the authors used the keyword. Figure 10c showed the visualisation of citations using articles while Figure 10d showed the visualisation of citations using 74 countries with at least three countries. As shown in the figure, most of the articles were cited by authors from the USA and China. The authors citing articles on seafood and antibiotics research were affiliated to 1173 institutions (Figure 10e).

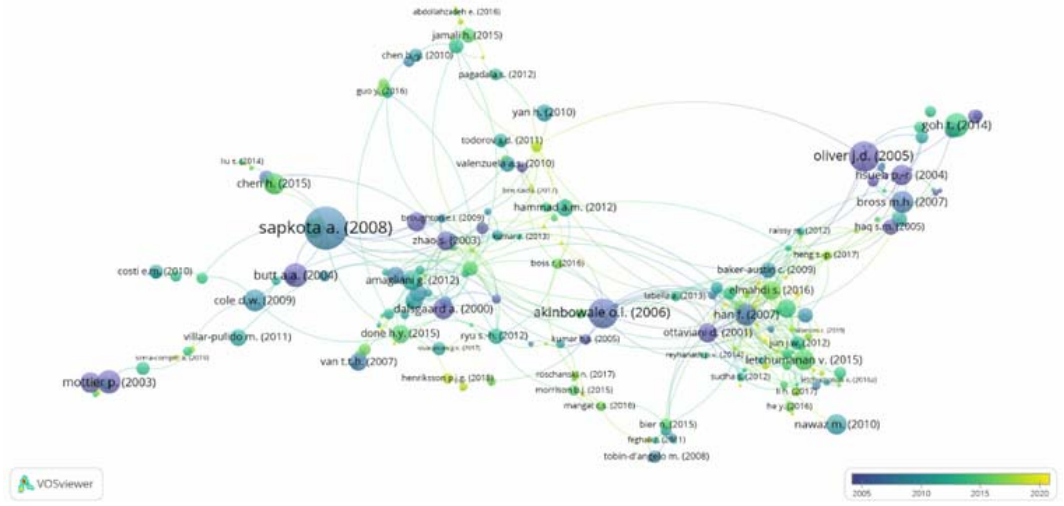

Fig. 10c. *Visualisation of citations using articles*

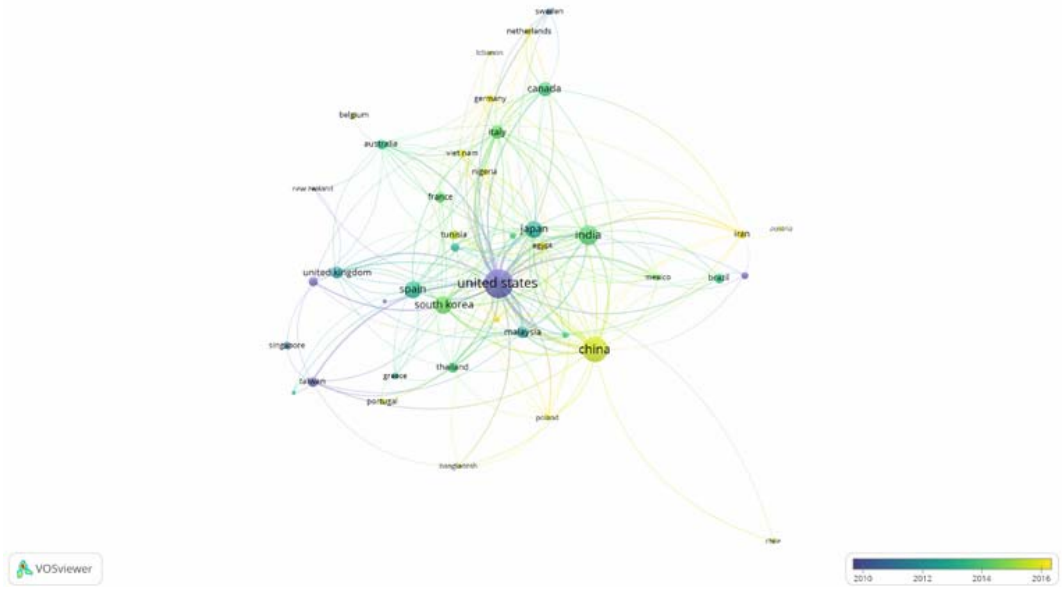

Fig. 10d. *Visualisation of citations using countries of 74 countries with at least three countries*

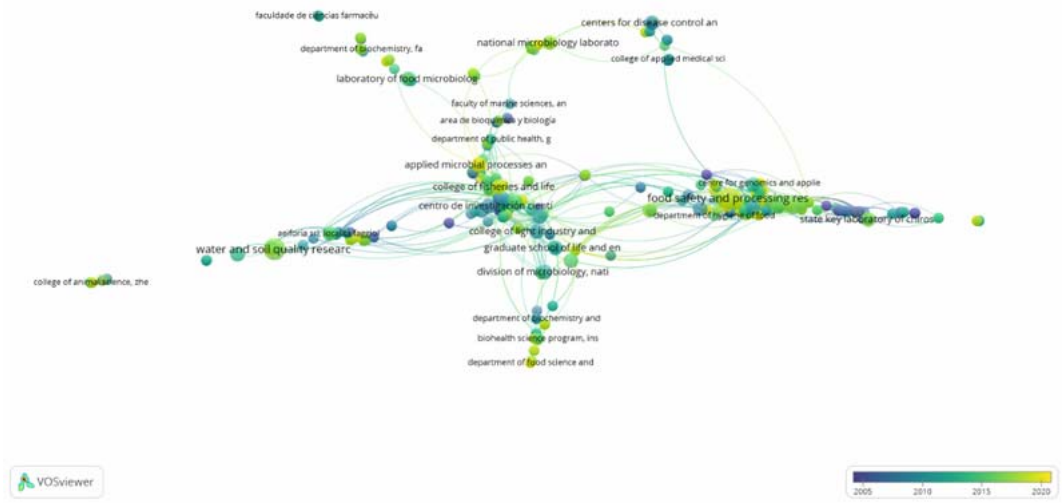

Fig. 10e. *Visualisation of citations based on 1173 affiliations*

4. Discussion

4.1. Quantity and Growth of the Research Output

This study is aimed at quantitatively analysing the global research trend involving the use of antibiotics either for treating diseases acquired through seafood-borne pathogens or the use of antibiotics in aquaculture farming. An exponential growth rate was observed in the number of research outputs thereby fulfilling Price's Law because the coefficient of regression (r^2) of the exponential curve was greater than that of the linear curve [29]. This signifies an increase in the interests of researchers in seafood and antibiotics which could be due to the increase in reported cases of emerging and re-emerging antibiotic resistance pathogens from seafood that could be transmitted to humans or animals because of an indiscriminate use of antibiotics [11]. This could be detrimental to the seafood industry aside public health as it could lead to huge economic loss because of product rejections [20]. Cases of antibiotic residues in seafood have been reported. For example, in Bangladesh residues of banned nitrofuran and chloramphenicol were detected in farmed freshwater prawn and shrimp meant for export and also in feed [20]. Similarly in Vietnam, enrofloxacin was detected in 15% (53/362) of samples of seafood analysed for the presence of antibiotics residue as reported by Uchida et al. [36]. Apart from antibiotics residues, antibiotic resistance genes in microbial flora of seafood have also been reported. Shah et al. [33] reported the occurrence of chloramphenicol and erythromycin resistance genes in bacterial flora in seafood from Africa and Asia (Tanzania and Pakistan). In India, antibiotic resistance genes in *Salmonella* isolated from seafood was reported [10] while an antibiotic resistant *Vibrio parahaemolyticus* isolated from seafood was also reported in Malaysia [35]. Similar observations have been reported in other parts of the world including Australia, Bulgaria, Italy, Canada, UK and USA [31]. This signifies the widespread use of antibiotics in aquaculture.

4.2. Authors' Preferred Journals and Subject Areas

The 10 topmost preferred journals observed in this study are mostly related to food and microbiology for publishing seafood and antibiotics related research outputs. For example, the International Journal of Food Microbiology which is the "official Journal of International Committee on Food Microbiology and Hygiene (ICFMH)" was the first most preferred journal. The journal has an impact factor of 4 and ranked as quartile 1 which is the best quartile in Food Science and Microbiology [42]. The impact factor of a journal is used to measure the quality of the journal and enhances the citation of the research outputs published by the journal [12]. The International Journal of Food Microbiology serves as a platform for publishing research relating to microbial food safety, food quality, and various aspect of microbiology such as bacteriology, parasitology, virology, mycology and immunology that are of public health importance. This was also reflected in the subject areas in which these research outputs were published. Most of the publications were in the Microbiology and Immunology subject areas. Publishing research outputs in the related subject area and journal will enhance the visibility, impact of the research and the sharing of scientific knowledge.

4.3. Analysis of Ten Most Active Authors

The ten most active authors on Scopus for the last two decades of publishing researches on seafood and antibiotics account for 12.3% of all publications. It is extremely important for scientific papers to be published in journals indexed in renowned international databases such as Web of Science and Scopus [28]. Moreover, many institutions analyse the number of publications by individual researchers along with the number of citations of these publications when making decisions for employment, promotion and tenure. Publications and citations of individual departments or faculties can also be analyzed for the assessment of their effect in a specific scientific area [9]. For the researched period, a total of 447 articles were found with a total of 2050 authors, which means an average of 1.6 authors per article.

4.4. The Most Productive Institutions and Countries

The National Centre for Toxicological Research (U.S. Food and Drug Administration - FDA) was the most active institution in the research on seafood and antibiotics. The mission of the centre is to provide FDA with studies needed for making stable regulatory decisions. This involves risk assessment of the use of consumer products regulated by FDA (human and animal drugs, biological products, food, medical and tobacco products) and developing better approaches for such risk assessment [16]. The geographical distribution of retrieved documents showed that the majority of the publications were from North America closely followed by Asia. The concentration of scientific research in specific countries and geographical regions means not only that they generate more and better knowledge than others, but also that they can direct orientation and priorities in these scientific studies. This refers predominantly to institutions

with worldwide established reputation. While institutions of this type have a decisive role to play in providing quality of life in their own countries, the knowledge they possess and create can be specialized and local and may not be efficiently applicable in other regions [18].

4.5. Analysis of Funding Institutions

The National Natural Science Foundation of China was the highest funding institution. In compliance with the strategies and plans of the Chinese government for the development of science and technologies, the foundation is responsible for the management, coordination and efficient use of the National Natural Science Fund for the support of major research. The Foundation stimulates free research, the identification and encouragement of scientific talent and progress in science and technologies as well as the social and economic development of the nation [39]. Governments usually sponsor most major scientific research activities and therefore contribute to a significant share of acquired knowledge and the resulting scientific publications generated through national investments in scientific research work. Public accountability is crucial for state agencies in many countries and it should reflect the efficiency of funding scientific research [38].

4.6. Network Visualisation: Citation Analysis and Co-Occurrence of Authors Keywords

The evolution of the electronic age has resulted in developing a number of databases offering the ability to search by specific subject and an opportunity for analysing citations [13]. The analysis of citations has been an object of research and discussions for decades. The analysis of citations and impact factor of journals are used to determine the value and significance of a journal or author. Citability of an author is used the participation in competitions for getting grants and holding positions. Due to numerous reasons, scientific workers want to point out the importance of their work and the analysis of citations is one of the ways to achieve that [4]. We found out that the most frequently cited journals were the International Journal of Food Microbiology, Food Microbiology and Applied and Environmental Microbiology. The impact factor of these journals is over 4, and in addition, they are classified in quartile 1 of Food Science and Applied Microbiology and Biotechnology, which logically makes them preferred for publication and citation. Out of the seventy-four countries observed, USA was the most cited. According to Coppen and Bailey [7] it is not surprising that the USA ranks first by number of citations per article in their study of the 20 most cited countries in clinical medicine. Citations are the best index of the scientific achievement of an article. Moreover, Ocholla et al. [28] found that Scopus scores more citations than Web of Science. Most journals usually request for the inclusion of at least three keywords during the submission of manuscripts for publication. These keywords are important sources of information that can help researchers to locate or identify related articles and increase the readability of such articles [37]. Similarly, the frequency of the use of keywords helps to determine research trends in a field [21]. In this study, both seafood and

antibiotic resistance were the most used authors' keywords apart from *V. parahaemolyticus*. This implies that the use of these keywords in articles relating to seafood and antibiotics will enhance the discoverability, readability and citation of such articles. Journals indexing databases such as Web of Science and Scopus also include keywords as features for easy search and retrieval of scientific articles testifying to the importance of the use of authors' specified keywords.

5. Study Limitations

There are limitations to this study such as the exclusion of publications that are not indexed in Scopus. The results obtained in this study were only based on the search of key words which could generate false positive and/or false negative results. To minimise this, only the abstract, titles and keywords of research outputs were screened for inclusion in this study. Another limitation was the use of only one database.

6. Conclusions

This study was able to demonstrate the exponential growth in global seafood and antibiotics research. Most of the research outputs were published in the International Journal of Food Microbiology. The majority of these research activities were from America, Asia and Europe. We observed fewer publications from Africa, hence the need for more scientific collaborations with well-established scientists around the world especially those in developed countries. In addition, due to financial constraints, researchers from developing countries mostly published their research outputs in journals that are not indexed in Scopus. There is therefore need for proactive funding of research to be published in reputable journals that are well indexed.

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