Scientometric analysis of research on Zika virus

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Abstract The research productivity on Zika virus (ZV) had been evaluated applying scientometrics. The different aspects of scientific literature on the subject under study accessible through ‘Scopus’ were explored. An advanced search was conducted in the database for ‘Zika’ and ‘Virus’ as main operators for analytical purposes. Search terms were connected using Boolean Operator ‘AND’ to retrieve relevant records. The search results were further filtered for journals articles. A total of 573 ZV associated records were retrieved including 6 duplicate items, after deleting which the relevant results remained 567. Lotka’s law was applied for assessing the author productivity and Bradford’s law of scattering was used to ascertain the distribution pattern of articles in journals. The results revealed a high degree of research/authorship collaborative on ZV. The authorship pattern did not fit to the Lotka’s law with a value of $n = 2$. The distribution of articles in journals was found nearly acceptable to the Bradford’s law of scattering, advocating the existence of a few core journals contributing significantly on ZV.

Keywords Scientometric · Bibliometric · *Zika virus* · *Flavivirus* · *Aedes mosquitos*

The Zika virus (ZV) is an emerging arbovirus belonging to the family *Flaviviridae* and genus *Flavivirus* [9], transmitted through the bite of an infected *Aedes* species mosquito. The ZV was first isolated from sentinel rhesus monkeys in the Zika Forest of Uganda in 1947 [3] and the

first human cases of this pathogen were detected in 1952 [7]. Initially described to be causing sporadic human infections in Africa and Asia, in 2007, the disease caused panic with Zika fever epidemics in Yap Island in the southwestern Pacific infecting 70 % of the island’s populations [4]. With the outbreak of disease in Brazil, America and other parts of the world beyond tropical areas of Africa, South-Asia and pacific islands, ZV has been declared a “public health emergency of international concern” by the World Health Organization (<http://www.who.int/mediacentre/news/statements/2016/emergency-committee-zika-microcephaly/en/>). A ZV outbreak started in French Polynesia, South Pacific in October 2013 [1]. Before 2007, there were 14 documented cases of ZV (<http://www.cdc.gov/zika/about/>), whereas in 2015, 440,000 to 1,300,000 estimated cases of the disease have been reported in Brazil only (<http://ecdc.europa.eu/en/publications/Publications/zika-virus-americas-association-with-microcephaly-rapid-risk-assessment.pdf>). In addition, cases have been reported in other countries in South America, Central America, and the Caribbean, as well as in the United States (<http://time.com/4193072/zika-virus-neglected-disease/>). According to the World Health Organization, during 1 January 2007–16 March 2016, ZV transmission has been documented in a total of 59 countries and territories (http://apps.who.int/iris/bitstream/10665/204633/1/zikasitrep_17Mar2016_eng.pdf). The symptoms of Zika Virus are not very clear, still the fever, rashes, joint pain, red eyes, muscle pain and headache are the most common. The incubation period for the disease also vary from a few days to a week after being bitten by an infected mosquito. The WHO warns to prepare for the health services for neurological syndromes and/or congenital malformations and potential disease complications not yet described in the scientific literature and clinical presentation among specific

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populations in the areas affected by ZV (<http://www.who.int/mediacentre/news/statements/2016/1st-emergency-committee-zika/en/>). The ZV has also raised attention to the possible deleterious effects that it may have on foetuses [12]. However, “there are no licensed medical counter measures (vaccines, therapies or preventive drugs) available for Zika virus infection and disease” [8]. In such a situation, studies on ZV are centric to the scientific interests. Research and scientific literature on ZV are basic for developing new therapeutic molecules. Bibliometric studies provide a snap-short of the research trends in respective subjects. These are applied to study the properties and behaviour of recorded knowledge and for evaluation of research activities and administration of scientific information [10]. Bibliometric analysis refers to the “statistical support device that allows mapping and generating different information and knowledge handling and management indicators, particularly in scientific, technological and productivity-related information and communication systems” [11]. Such studies not only correlate the need for research in certain conditions, but also provide an accurate overview of the scientific output over and time and its future impact, helping the library and information professionals in collection and organization of information resources relevant to the interests of stakeholders. In place of bibliometrics, the term scientometrics is used more preferably for measuring and analysing science, technology and innovation. The present study aimed at scientometric analysis of research outcome on ZV by examining the chronological growth of literature on the subject, authorship pattern and author productivity, fitness of distribution of articles to Bradford’s law of scattering and geographical distribution of scientific literature. An attempt was also made to identify the core journals publishing articles on ZV.

For the purpose of study, data was accessed in the end of March 2016 using ‘Scopus’ database. To access bibliographic information of scientific publications on ZV, an advanced search was conducted in Scopus using ‘Zika’ and ‘Virus’ as main operators connected by Boolean operator ‘AND’ to get relevant results. The results were further filtered for journal articles. In total 573 records were retrieved. The data was downloaded in CSV format and then converted to Microsoft Excel for analysis. However, there were six duplicate records in the results retrieved, which were removed from the Microsoft Excel sheet. Hence, the results and findings of study are based on remaining 567 unique records. The data had been analyzed using percentage calculations.

The results revealed that though the history of ZV is traced back to 1947, the disease got serious attention of the scientific community during recent years. Around 12.87 % of the 567 articles on ZV had been contributed during first quarter (January–March) of 2016. The year 2015 witnessed

publication of 14.46 % articles followed by 2014 with addition of 08.47 % papers. Owing to occasional identification of cases of *Zika virus* particularly in African countries, the second half of twentieth century produced only 100 articles on the disease, whereas remaining majority (82.36 %) were contributed during 2001–March 2016. This supports the observations of Parson (<http://time.com/4193072/zika-virus-neglected-disease/>) that the disease has been neglected for the long time. Out of total 567 articles under study, author information was available for 562, whereas in case of remaining 5 papers author names were unidentified. In total, 2640 authors contributed 562 articles averaging 4–5 authors per paper. All but 11.03 % (62) articles had been contributed in joint authorship. The number of articles along with number of authors (1 to >10) with percentages in parentheses are given in Figure 1, which had been prepared using Microsoft-Excel programme. Around 14.41 % contributions were made by two authors and 14.23 % by four authors. Nearly 12.28 % articles had been written by four authors each. Around 10.32 % contributions had more than ten authors. The results make it obvious that in view of the emergency to tackle the virus, organized research efforts were being made throughout the world. The degree of authorship collaboration on the subject was calculated using the formula given by Subramanian [13]:

$$C = \frac{Nm}{Nm + Ns}, \quad C = \frac{500}{500 + 62} = 0.8896$$

(C = degree of collaboration, Nm = number of multi-authored works, and Ns = number of single-authored works).

Fig. 1 Authorship pattern based on the number of contributors to each article

The author productivity on ZV had been tested considering first author viz-a-viz all authors of the articles. Considering the first author of each paper, total 504 authors contributed to 562 articles. Around 91.46 % authors contributed one articles each on the subject, 06.74 % added two articles and 04 authors contributed 3 and 4 articles each, respectively. An author contributed 5 articles. Similarly, considering all authors, total 2640 authors contributed to 562 articles. Around 86.70 % authors contributed one article each, 09.05 % added two articles, 02.28 % contributed to three articles and 1.10 % added 4 articles. An author contributed to 11 papers on ZV. The Lotka's law was applied to calculate the number of expected authors for published articles. Considering the fact that 461 and 2289 authors contributed single article using first author and all authors, respectively, the number of expected authors had been obtained putting the value of n as '2'. The results revealed that a great majority of authors contributed on ZV occasionally. Hence, the author distribution did not fit to Lotka's law. A considerable difference had been found between the number of observed and expected authors on ZV. Out of total 2640 authors, 112 authors contributed to 437 papers constituting 77.75 % of the total articles under study.

Bradford's law of scattering depicts the distribution of articles on a given subject in journals [2]. The law is based on the principle of centric productivity zones, advocating the diminishing returns when literature is published exhaustively. According to the Bradford's law, the distribution of articles works on the expression $1:n:n^2$, distinguishing the group of journals dedicated more specifically to a subject. The number of journals in each zone can be calculated from Bradford multiplier constant k . In this study the mathematical formulations of Egghe [5] and Egghe and Rousseau [6] had been applied to drive the constant k as given below:

$$k = (e^\gamma \times Y_m)^{1/p}$$

where γ is Euler's number having value .57772. Y_m is the number of articles published in the top-ranked journal and p is Bradford's groups or number of zones i.e. $p = 3$

Therefore

$$k = (1.781 \times 23)^{1/3} = 3.4471796596$$

The different Bradford's groups had been calculated using k . The nucleus zone r_0 can be defined as:

$$r_0 = \frac{T(k-1)}{(k^p-1)}$$

The 'T' represents a total number of journals under the study.

$$\begin{aligned} r_0 &= \frac{293(3.45-1)}{(3.45^3-1)} \\ &= \frac{717.85}{40.06} = 17.91 \end{aligned}$$

Different Bradford's zones had been obtained using the value of k and r_0 :

$$\text{Nucleus zone } r_0 = r_0 \times 1 = 17.91$$

$$\text{First zone } r_1 = r_0 \times k = 17.91 \times 3.45 = 61.78$$

$$\text{Second zone } r_2 = r_0 \times k^2 = 17.91 \times 3.45^2 = 213.17$$

$$\text{Hence, Bradford's' distribution} = 17.91 + 61.78 + 213.17 = 292.86$$

$$\text{Percentage of error} = \frac{292.86 - 293}{293} \times 100 = 0.047 \%$$

The theoretical distribution of Bradford's law had been used to examine the exact fit of the law to the distribution of articles on ZV. The three zones of journals along with number of articles in each zone were arrived. The value of k 3.44 for Zone 1 and 3.43 for Zone 2 had been found almost similar to the value of k calculated using the formula $k = (e^\gamma \times Y_m)^{1/p}$. The percentage of error (i.e. 0.047 %) was also insignificant. This made it imperative that the distribution of articles on ZV in journals was almost fit to the three zones of Bradford's Law of Scattering i.e. $1:k:k^2$ or $1:n:n^2$.

The total 567 articles on ZV were published in 293 journals, including 20 journals publishing 30.87 % of the total articles published on ZV. The *Transactions of the Royal Society of Tropical Medicine and Hygiene* tops the list with highest number of articles (23), followed by *Eurosurveillance* (14), *Morbidity and Mortality Weekly Report* (13), *American Journal of Tropical Medicine and Hygiene* (11), *PLoS Neglected Tropical Diseases* (11) and *PLoS ONE* (11). The distribution of 567 articles in 293 journals supported the concept of core journals. The place of publication of journals had been taken as a guide to the geographical distribution of publications. In total 28 countries contributed 293 journals publishing 567 articles on ZV. The United States occupied the top position in terms of contribution of number of journals viz-a-viz number of articles on ZV published in those journals. The United Kingdom grabbed the second position with the Netherlands as third largest contributor of number of journals and articles published. This makes it pertinent that the United States and United Kingdom were leading the world in terms of research and scientific activities on ZV. Germany, Switzerland and France were other major nations publishing literature on ZV. Eight journals published from India included 11 articles on the subject. With respect to the institutional contribution, the *Centre for Disease Control and Prevention* occupied the top position in terms of

contribution of articles, followed by Institut Pasteur, Paris, Institut Louis Malarde, UT Medical Branch at Galveston and The University of North Carolina at Chapel Hill with contribution of 10 or more articles.

The results of the study lead to the conclusion that research and scientific activities on Zika virus got impetus during last few years after the outbreak of disease out of South-African and Asian countries. A high degree of authorship/scientific collaboration on the subject had been observed. However, majority of authors contributed on ZV occasionally and author productivity did not fit to Lotka's law, as the observed and expected values considering both first author viz-a-viz all authors of the articles varied significantly. The distribution of papers in journals supported the Bradford's law of scattering identifying 18 journals in the core zone. This can be helpful to the libraries of institutions working on ZV to provide access to relevant journals to the scientific fraternity and make optimum utilization of funds with subscription of core journals publishing articles on the subject. The Centre for Disease Control and Prevention, United States played the leading role in scientific activities on ZV. In coming years, citation analysis of scientific articles on ZV will be eloquent to find most valuable works on the subject.

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