A Bibliometric Analysis of Dengue Fever Publications in Malaysia (1981 - 2017)

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ABSTRACT: *Dengue fever is a mosquito-borne neglected tropical disease affecting tens or hundreds of millions of people, with over ten thousand fatalities every year. More research is needed to help eradicate it or reduce its prevalence. Some of this research needs to be region-specific to deal with public health issues. This article analyses dengue-related publications from one of the affected countries, Malaysia, to assess the growth, prevalence, and subjects of published journal articles. The overall research design was to identify a collection of articles published in PubMed database and indexed in the WoS Core Collection and then produce a bibliometric profile of scientific publication. Malaysian research has increased in line with the growth of the disease, covering the four major topics of public health, mosquitos, the virus, and medical detection/intervention. Malaysian dengue research is almost always multi-authored, usually involves more than one institution and often includes international collaboration. For all research, the first author is Malaysian (71%). Although Malaysian research is often published in relevant local journals, such as Tropical Biomedicine (8%), articles in international journals have more impact. Overall, the results point to Malaysia possessing an increasing amount of academic expertise in all fields relevant to the Dengue virus, which must be exploited to control infection rates to aid the infected patients.*

Keywords: Dengue, Malaysia, Bibliometrics

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1. Introduction

Dengue fever is a viral infection carried and transmitted by the Aedes aegypti mosquito and Aedes albopictus mosquito in the tropics and its severe forms (hemorrhagic fever and shock syndrome) can be fatal (WHO 2009). The process starts with a sudden high fever, then a body rash, then crushing headaches and retroorbital (behind the eye) pain, which also sometimes involves severe musculoskeletal pain (McKenna 2012; Bhardwaj 2014a, 2014b). There are different dengue serotypes and different grades. These are dengue fever (DF), dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS) (Ranjit & Kissoon 2011; Lashley 2007). Most dengue cases are asymptomatic or mild but DHF and DSS can be fatal. Immunity to one serotype does not give immunity to the others and increases the risk of future infections being serious (Ho, Siu & Chuang 2016). One of the earliest recorded cases of dengue was from 1779 in Indonesia (Hanley & Weaver 2010) and DHF was reported as a new disease for the first time in 1953 in the Philippines (Belal & Shakeel 2011).

Dengue infections have been increasing alarmingly, with about 2.5 billion people living in more than 125 dengue endemic countries (Liew et al. 2016; WHO 2009, Bhatt et al. 2013, Murray, Quam & Wilder-Smith 2013; Maula, Fuad & Utarini 2018), particularly in the Asia-Pacific region (Maula, Fuad & Utarini 2018). This region recorded 451,422 dengue cases in 2015, with 1.8 billion people being at risk (WHO 2017). Indonesia recorded the second highest number of dengue cases in 2004-2010, behind Brazil (Kementerian Kesehatan 2015). Within Southeast Asia dengue is also a problem in Thailand, Malaysia, and Singapore. The prevalence of dengue in Indonesia could be attributed to the country's absence of effective treatment, and lack of comprehensive vector control and successful public health interventions (Maula et al. 2018). Dengue brings a total annual cost of $950 million in Southeast Asia (Shepard, Undurraga, & Halasa 2013), including due to time, hospital beds, direct and personnel costs (Liew et al. 2016; WHO 2012; Cucunawangsih & Lugito 2017). Even in the small country of Myanmar there were 89,832 recorded dengue cases from 2011 to 2015 and 393 resulted in death (Oo et al. 2017).

Researchers have discovered some core properties of Dengue and information about risk factors. According to the World Health Organization (WHO) social factors are behind the high occurrence of dengue cases in semi-urban areas (WHO 2017). These problems include unplanned urban development, poor water storage practices, and unsatisfactory sanitary conditions. Moreover, urbanization, globalization, and population density increases also contribute to the spread of the disease (Kyle & Harris 2008). A lack of environmental management also contributes to the rise and spread of dengue in almost all tropical and subtropical regions (Cucunawangsih & Lugito 2017). Other possible factors include global climate change, unsuccessful vector (mosquito) eradication, and precipitation (Dhara, Schramm, & Luber 2013; Cucunawangsih & Lugito 2017). Of these, vector control seems to be the best way to prevent and control dengue (Murray, Quam & Wilder-Smith 2013). This includes discarding tins, water tanks, and flower pots that contain the stagnant water needed for mosquito breeding. Thus, although current research has suggested solutions for dengue, since they have not yet translated into reduced infection rates, it would be useful to take a broader perspective through a bibliometric study of dengue research. There is also a need to conduct a region and country-specific bibliometric study, especially in Southeast Asia, since it is known that dengue has a regional specificity character (Ho et al. 2016). This article focuses on Malaysia, one of the countries most affected by this disease.

1.1 Dengue in Malaysia

Dengue in Malaysia was first documented in Penang in 1902 (WHO-SEARO 2011). An outbreak was recorded in Penang in 1962 involving 41 dengue cases, with 5 death. A series of outbreaks followed in 1973 (1,487 cases, 54 deaths), 1974 (2,200 cases, 104 deaths), and 1982 (3,006 cases, 35 deaths) (Mudin 2015). Since then, a steady increase has been observed with 6.5 times more infections in the last decade (Ministry of Health Malaysia 2010a, 2010b; Liew et al. 2016; Mudin 2015). In 2014 there were 108,698 cases at a rate of 361.1 cases per 100,000 people, mainly from the Klang Valley area (56%), which includes Selangor (49%) and the Federal Territory of Kuala Lumpur-Putrajaya (7%). In response, the Malaysian government established the “Dengue Virus Surveillance System (DVSS)” to collect samples on a weekly basis from all 14 states. Dengue cases in Malaysia are now reported online to the district health authorities, when diagnosed clinically, with or without serological confirmation (Liew et al. 2016).

A few academic studies on dengue have been conducted in Malaysia. These studies include a review of dengue research (Cheah et al. 2014), dengue infection trends (Mia et al. 2013; Bujang et al. 2017), and factors associated with dengue mortality (Liew et al. 2016). A public information study also found moderate levels of knowledge or information about the disease and its causes as seen among Malaysian students (Lugova & Wallis 2017). Thus, there is a lack of knowledge about Malaysia-specific factors, despite the recognition of the importance of the disease by the Malaysian government and NGOs, specifically in applying Integrated Vector Management (IVM), dengue surveillance, early treatment, and social mobilization (Sulaiman & Choy 2016).

1.2 Bibliometric Analysis

Bibliometric analyses of research fields typically involve identifying and tracking the scholarly impact of relevant publications (Sam 2008; Milojeviæ & Leydesdorff 2013; Osei & Ho 2018). This process involves a quantification and assessment of the research outputs of researchers, research institution, academic institutions and countries (Aswathy & Gopikuttan 2013; Noruzi & Abdekhoda 2014). Patterns are investigated in this quantitative study including those relating to the expansion of literature, interrelationship of knowledge, productivity, authorship, collaboration, and use of literature in scientific writing (Morillo, Bordons & Gomez 2001). The standard evidence used for the academic impact of publications is the citation count (Wohlin 2005). Citations ensure the continuity of knowledge within a field and help to situate a study’s contribution to its discipline (Ho & Kahn 2014).

Bibliometric studies have often focused on broad domain topics rather than fields. Ho and Kahn (2014) cited some notable examples of studies in the medical field that made use of bibliometric analysis including those that studied water resources (Chuang, Wang, & Ho 2011), anesthesia (Baltussen & Kindler 2004), surgery (Brooke, Nathan, & Pawlik 2009), Parkinson’s disease (Ponce & Lozano 2011), depression (Lipsman & Lozano 2011), Hepatitis B (Ramakrishnan & Rajendran 2004), Hepatitis C (Ramakrishnan & Thavamani 2012), diabetes (Krishnamoorthy, Ramakrishnan & Devi 2009), and HIV/AIDS (Ramesh Babu & Ramakrishnan 2010). More recent bibliometric analysis have investigated chikungunya, (Vera-Polania et al. 2015; Muñoz-Urbano et al. 2014), West Nile virus [1], yellow fever (Bundschuh et al. 2013), Zika virus (Martinez-Pulgarin et al. 2016), Ebola (Hagel et al. 2017), cardiovascular diseases (Saquib et al. 2017), and other tropical diseases (Reidpath, Allotey & Pokhrel 2011).

Reidpath, Allotey & Pokhrel (2011) reported bibliometric statistics on dengue as part of the general classification tropical diseases. Dengue had the most publications (2,344) in health social sciences papers from 2000 to 2009. This is in comparison to the papers published on visceral leishmaniasis (1,648), onchocerciasis (483), and chikungunya (274).

A bibliometric analysis of international dengue research was conducted a decade ago with the Web of Science (WoS),

including papers published from 1987 to 2008 (Dutt, Kumar, and Garg, 2010). Most of the papers (80%) were published by scientists in western countries, such as the United States, the United Kingdom, the Netherlands, France, and Germany (for an update, see: Mota et al. 2017) compared to ASEAN countries. According to Nguyen (2011), the factors that leads to these issues are related to knowledge economy index (KEI), knowledge index (KI), innovation, and information and communication technology (ICT), research area, language and policy. As an example, Singapore spent heavily in science and technology (Arunachalam and Garg,1985), but other countries such as Vietnam and Indonesia have much lower investment. Due to that, not surprising that the publication output from Vietnam, Indonesia and the Philippines is still moderate compared with Singapore, Thailand, and Malaysia. As Vietnam had been at war with various powers for almost 100 years, other countries in the region had experienced a long period of economic stability. However, the policy of "renovation" was introduced after a long period of political isolation and economic crisis has increased the scientific research in Vietnam and starting 2000 the scientific output from Vietnam has been rapidly increase.

A later scientometric study identified 9,618 dengue-related papers published in Scopus from 2001 to 2012. Mahidol University in Thailand, which contributed 353 published studies, was the only Southeast Asian university to make a substantial contribution (Bhardwaj, 2014a, 2014b). A study of 7,746 dengue-related articles in the Science Citation Index Expanded from 1991 to 2014 found that 96% were written in English and were mostly from the USA, Southeast Asia and Western Europe (Ho, Siu & Chuang 2016). Countries from Southeast Asia (Thailand, India, Singapore and Taiwan) and South America (Brazil) published a higher percentage of dengue-related publications than western countries, even though their contributions were numerically small (Ho et al., 2016). A bibliometric study of 1872 to 2015 found 19,581 dengue-related documents in Scopus with a noticeable increase after the year 2000 (Zyoud 2016). A mathematical paper has also investigated the distribution of dengue author productivity (Sadik 2018).

One previous study has shown that Malaysia has published at least 100 dengue articles (Ho, Siu & Chuang 2016). Despite being one of the hardest hit countries in Southeast Asia and one of the few Southeast Asian countries that collaborates with Arab and western countries for dengue-related research, Malaysia's research publications have not yet been systematically analyzed using bibliometrics. A review of 166 research articles related to dengue in Malaysia found topic themes but did not identify bibliometric trends (Cheah et al. 2014). A quantitative and spatial analysis of dengue in Malaysia also did not use bibliometric methods (Mohd-Yajid, Dom & Camalxaman 2018).

As introduced above, it is important to conduct region-specific studies of dengue, including from a bibliometric perspective, and there is a lack of relevant investigations for Malaysia. It is useful to compare the burden of diseases with the research on those diseases (Griswold et al. 2018; Saquib et al. 2017; Zunt et al., 2018) but few studies have been conducted on the burden of dengue (Oo et al. 2017) especially in Malaysia, and this is another gap that this study addresses. The following specific research questions are the focus of this paper.

1. What are bibliometric characteristics of scientific publications about dengue fever authored in Malaysia from 1980 to 2017?
2. Which fields published dengue research between 1980 to 2017?
3. What is the relationship between the incidence of dengue fever and the number of scientific publications in Malaysia?

2. Materials and Method

The overall research design was to identify a collection of articles published in PubMed database and indexed in the WoS Core Collection and then to examine these articles and produce a bibliometric profile of scientific publication including the trends and subject fields of dengue fever. The data were collected during October 2017. Two queries were designed to identify all papers published related to dengue by Malaysian-based authors (Table 1). Each query was based around the single term dengue since this is an unambiguous word with no synonyms (e.g., break bone disease) that are likely to be used in academic publications that do not also use the term dengue.

Full bibliographic information on publications matching the queries and having a PubMed ID was recorded. Only articles from PubMed were included because PubMed is part of the US National Institute of Health's searchable database that includes 29 million citations for scientific and medical literature from MEDLINE, life science journals, and online books. All records were screened manually and sorted according dedicated unique ID, year and title. Any articles published with incomplete metadata and broken records were excluded. After cleaning the data, a total of 400 Malaysian articles were used for further analysis, and 12558 international articles.

3. Results

3.1 Characteristics of scientific publications about dengue fever authored in Malaysia from 1980 to 2017

Web of Science*	**Malaysia**	**Worldwide**
Search Language	TOPIC = (dengue) AND ADDRESS = (Malaysia) AND DOCUMENT TYPES =(Article)Refined by: LANGUAGES = (ENGLISH)	TOPIC = (dengue) AND DOCUMENT TYPES =(Article)Refined by: LANGUAGES= (ENGLISH)
Timespan	All years	All years
Articles	538	14,593
Articles with PubMed ID	400	12,558

Table 1. Records of Malaysian and international English dengue articles in the Web of Science

As indexed in WoS, the first dengue-related journal article was published in 1980 and within the last 10 years, the number of WoS dengue articles increased significantly (a three-fold increase) (Figure 1). The first Malaysian journal article was published in 1981 and the rate of publication growth for Malaysia (Figure 2) has broadly mirrored that of the world.

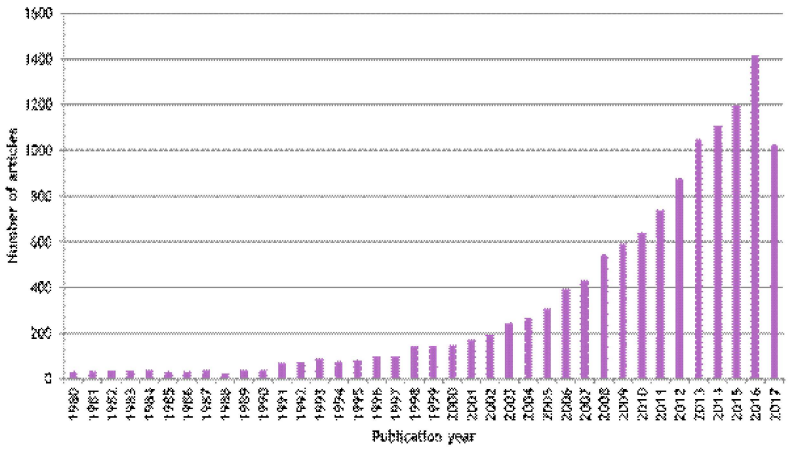

Figure 1. WoS dengue publications 1980-2017

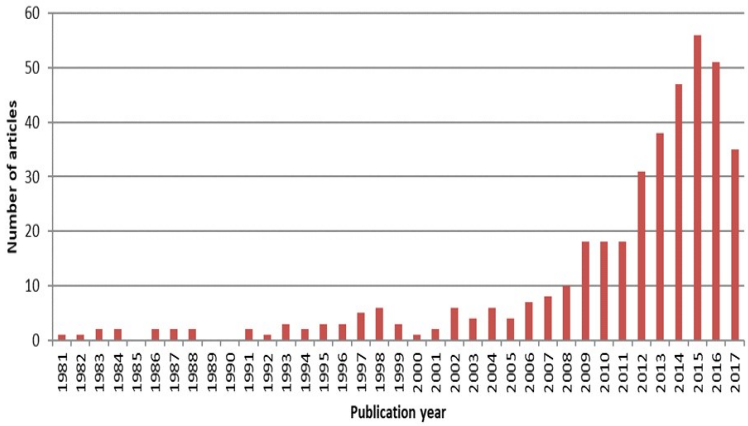

Figure 2. WoS dengue publications 1981-2017 with at least one Malaysian author

Research on dengue is reported mainly in the journal of tropical medicine, infectious disease, pathology, and public health. A total of 8% of the articles from Malaysia were published in the journal Tropical Biomedicine, published by Malaysian Society of Parasitology and Tropical Medicine. This was the most popular journal for Malaysian dengue articles. Although fewer Malaysian dengue articles were published in Plos One, (5%), they attracted three times as many citations. In general, papers published in international or American journals had a greater citation impact than local journals. Please refer to Table 2.

No.	Journal	Total Number of Articles (%)	IF_{2017}	Web of Science Category	Total Citations
1	Tropical Biomedicine	32 (8)	0.719	Parasitology; Tropical Medicine	242
2	Plos Neglected Tropical Diseases	22 (5.5)	3.834	Infectious Diseases; Parasitology; Tropical Medicine	432
3	Plos One	20 (5)	2.806	Multidisciplinary Sciences	308
4	American Journal of Tropical Medicine and Hygiene	19 (4.75)	2.549	Public, Environmental & Occupational Health; Tropical Medicine	748
5	Journal of the American Mosquito Control Association	16 (4)	0.860	Entomology	99
6	Southeast Asian Journal of Tropical Medicine and Public Health	12 (3)	0.655	Public, Environmental & Occupational Health; Infectious Diseases; Tropical Medicine	121
7	Parasites Vectors	10 (2.5)	3.035	Parasitology	57
8	Acta Tropica	9 (2.25)	2.218	Parasitology; Tropical Medicine	34
9	Journal of Vector Ecology	8 (2)	1.473	Entomology	52
10	Scientific Reports	8 (2)	4.259	Multidisciplinary Sciences	60

Table 2. Journals publishing the most Malaysian dengue articles

Type	Organization	Papers	%
University	Universiti Malaya	204	51.0
University	Universiti Sains Malaysia	71	17.8
Research Center	Institute Penyelidikan Perubatan	47	11.8
University	Universiti Kebangsaan Malaysia	39	9.8
University	University of Malaysia Sarawak	31	7.8
Ministry	Kementerian Kesihatan Malaysia	28	7.0
University	Universiti Putra Malaysia	25	6.3
University	Universiti Teknologi Mara	22	5.5
Agency	Hosp Kuala Lumpur	10	2.5
University	Monash University Sunway	8	2.0
University	International Medical University Malaysia	6	1.5
University	Perdana Univ, Maeps	4	1.0
Agency	Hosp Kota Bharu	4	1.0
Research Center	Institute Penyelidikan Dan Kemajuan Pertanian	3	0.8
University	Universiti Malaysia Pahang	3	0.8
University	Universiti Malaysia Sabah	3	0.8
University	Universiti Malaysia Terengganu	3	0.8
University	University of Malaysia Perlis	3	0.8
Agency	Hosp Tengku Ampuan Afzan	3	0.8
University	Aimst University	2	0.5

Table 3. Malaysian organization publishing the most dengue-related journal articles

Nearly all (99%) of the 400 Malaysian papers had multiple authors. This probably reflects the need for teams of people to conduct medical studies or health-related surveys. the main international contributors are the USA, England, Singapore and

Rank	Country	Articles	%	First Authored	%
1	Malaysia	400	100.0	283	70.8
2	USA	48	12.0	16	4.0
3	England	37	9.3	13	3.3
4	Singapore	32	8.0	14	3.5
5	Japan	28	7.0	6	1.5
6	Thailand	27	6.8	4	1.0
7	Australia	23	5.8	11	2.8
8	Vietnam	23	5.8	5	1.3
9	India	15	3.8	8	2.0
10	Saudi Arabia	15	3.8	2	0.5
11	Germany	13	3.3	8	2.0
12	Indonesia	13	3.3	1	0.3
13	Peoples R China	13	3.3	2	0.5
14	France	12	3.0	1	0.3
15	Italy	12	3.0	1	0.3
16	Philippines	12	3.0	1	0.3
17	Switzerland	12	3.0	3	0.8
18	Cuba	11	2.8	2	0.5
19	Taiwan	11	2.8	1	0.3
20	Brazil	10	2.5	0	0.0
21	Cambodia	8	2.0	1	0.3

Table 4. Countries collaborating most with Malaysia for dengue-related journal articles

Collaboration Type	Articles
University with university	146
University with agency	25
University with research center	21
Research center with research center	9
Agency with agency	5
University with ministry	2
University with research center and ministry	2
University with agency and research center	2
University with agency and ministry	1
Agency with ministry	1
Agency with research center	1
Research center with ministry	1
Total number of articles	**216**

Table 5. Types of collaboration within Malaysia for Malaysian dengue-related journal articles

Japan. In addition, 71% of the 400 articles have a Malaysian first author, showing that Malaysia usually leads dengue research. Just over 54% of Malaysian articles include collaboration between different Malaysian organisations (Table 5).

From the collaboration data obtained, Malaysia has conducted research collaborations with developed countries such as the USA, England, and Singapore. With this network, it increases the number of publications of researchers from Malaysia in international larger citation index databases such as WOS and Scopus. Starting 2010, most universities in Malaysia especially the research universities focus on international research collaboration. As a results, international collaboration fund has been established under the Malaysian Science and Technology Information Centre (MASTIC) and several international research grants received by Malaysian researchers especially in science fields.

WoS category	Papers	Percent (%)	Journals
Tropical Medicine	130	32.5	15
Parasitology	83	20.8	9
Public Environmental Occupational Health	67	16.8	16
Infectious Diseases	66	16.5	20
Virology	38	9.5	15
Multidisciplinary Sciences	33	8.3	6
Entomology	27	6.8	5
Immunology	23	5.8	17
Biotechnology Applied Microbiology	22	5.5	10
Microbiology	22	5.5	13
Medicine General Internal	20	5.0	12
Biochemistry Molecular Biology	19	4.8	14
Biochemical Research Methods	14	3.5	6
Biophysics	10	2.5	7
Chemistry Analytical	10	2.5	7
Chemistry Multidisciplinary	8	2.0	4
Computer Science Interdisciplinary Applications	8	2.0	4
Mathematical Computational Biology	8	2.0	4
Genetics Heredity	7	1.8	6
Pharmacology Pharmacy	7	1.8	6
Chemistry Medicinal	6	1.5	5
Integrative Complementary Medicine	6	1.5	1
Nanoscience Nanotechnology	6	1.5	3
Pediatrics	6	1.5	4
Electrochemistry	5	1.3	2
Engineering Biomedical	5	1.3	3
Environmental Sciences	5	1.3	4
Medical Informatics	5	1.3	3
Medicine Research Experimental	5	1.3	4
Cell Biology	4	1.0	4

Table 6. WoS subject categories of Malaysian dengue-related journal articles

3.2 Subjects field of Malaysian dengue research

Most Malaysian dengue-related journal articles are published in medical categories within WoS, although 17% are in Public, Environmental and Occupational Health (Table 6). Except for Virology, the main categories have all recently experienced rapid growth (Figure 3).

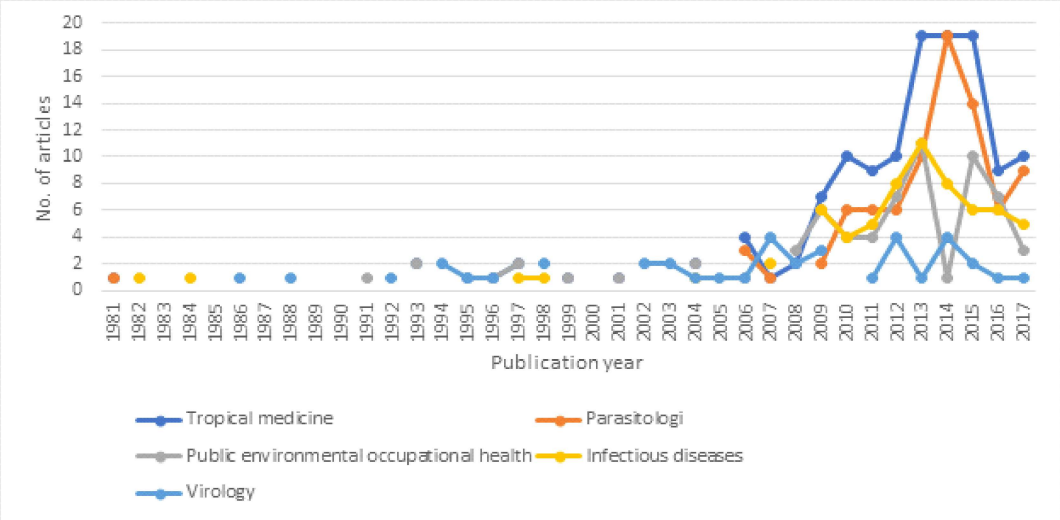

Figure 3. WoS dengue publications 1980-2017 from Malaysia by subject category

The keywords mapping was conducted using VOSviewer. The co-occurrence analysis was conducted using all keywords (author keywords and KeyWords plus). From the total of 1817 keywords, the top 5 highest keywords frequency are dengue (94), hemorrhagic-fever (83), culicidae (43), infection (43) and malaysia (34). Figure 4 shows the keyword mapping, with size of nodes demonstrates the frequency of keyword's occurrence, while lines show relationships among keywords.

The co-occurrence analysis identified high-frequency keywords and categorized them into 4 clusters corresponding with the areas of research on dengue: dengue vector; human infection and antibodies; dengue as epidemic; and transmitted infection.

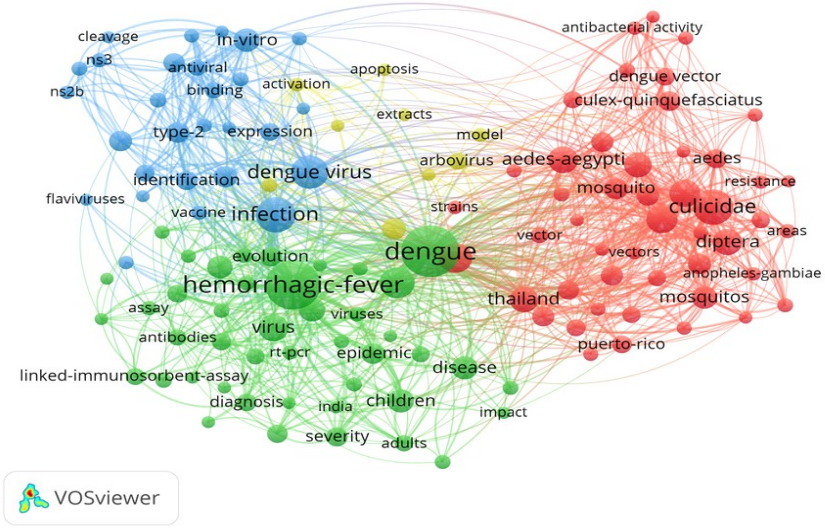

Figure 4. Keywords mapping of dengue journal articles (VOSviewer).

The most cited dengue-related journal articles with a Malaysian author tend to be international collaborations, and often published in prestigious international journals (Table 6). The citation counts for the most recently published articles are likely to be substantial underestimates of their eventual total.

Title	Year	Journal	Authors	Cites
Localization of dengue virus in naturally infected human tissues, by immunohistochemistry and in situ hybridization	2004	Journal of Infectious Diseases	Jessie, K; Fong, MY; Devi, S; Lam, SK; Wong, KT	319
Clinical efficacy and safety of a novel tetravalent dengue vaccine in healthy children in Asia: a phase 3, randomised, observer-masked, placebo-controlled trial	2014	Lancet	Capeding, MR; Tran, NH; Hadinegoro, SRS; et al.	303
Origin and evolution of Japanese encephalitis virus in southeast Asia	2003	Journal of Virology	Solomon, T; Ni, H; Beasley, DWC; et al.	221
Efficacy and Long-Term Safety of a Dengue Vaccine in Regions of Endemic Disease	2015	New England Journal of Medicine	Hadinegoro, SR; Arredondo-Garcia, JL; Capeding, MR; et al.	191
Cost of Dengue Cases in Eight Countries in the Americas and Asia: A Prospective Study	2009	American Journal of Tropical Medicine and Hygiene	Suaya, JA; Shepard, DS; Siqueira, JB; et al.	162
Evaluation of diagnostic tests: dengue	2010	Nature Reviews Microbiology	Peeling, RW; Artsob, H; Pelegrino, JL; et al.	158
Dengue encephalitis: A true entity?	1996	Amer. J. Tropical Medicine and Hygiene	Lum, LCS; Lam, SK; Choy, YS; et al.	154
Classifying dengue: a review of the difficulties in using the WHO case classification for dengue haemorrhagic fever	2006	Tropical Medicine & International Health	Bandyopadhyay, S; Lum, LCS; Kroeger, A	120
Pathophysiologic and prognostic role of cytokines in dengue hemorrhagic fever	1998	Journal of Infectious Diseases	Bethell, DB; Flobbe, K; Phuong, CXT; et al.	112
Clinical diagnosis and assessment of severity of confirmed dengue infections in Vietnamese children: Is the world health organization classification system helpful?	2004	American Journal of Tropical Medicine and Hygiene	Phuong, CXT; Nhan, NT; Kneen, R; et al.	105
Sylvatic transmission of arboviruses among Bornean orangutans	2001	Amer. J. Tropical Medicine and Hygiene	Wolfe, ND; Kilbourn, AM; Karesh, WB; et al.	97
Isolation of subgenus B adenovirus during a fatal outbreak of enterovirus 71-associated hand, foot, and mouth disease in Sibu, Sarawak	1999	Lancet	Cardosa, MJ; Krishnan, S; Tio, PH; et al.	97
Evaluation of a commercial dengue NS1 antigen-capture ELISA for laboratory diagnosis of acute dengue virus infection	2007	Journal of Virological Methods	Kumarasamy, V; Wahab, AHA; Chua, SK; et al.	96
Evaluation of commercially available anti-dengue virus immunoglobulin M tests	2009	Emerging Infectious Diseases	Hunsperger, EA; Yoksan, S; Buchy, P; et al.	94
Inhibitory activity of cyclohexenyl chalcone derivatives and flavonoids of fingerroot, Boesenbergia rotunda (L.), towards dengue-2 virus NS3 protease	2006	Bioorganic & Medicinal Chemistry Letters	Kiat, TS; Pippen, R; Yusof, R; et al.	93
Multicentre prospective study on dengue classification in four South-east Asian and three Latin American countries	2011	Tropical Medicine & International Health	Alexander, N; Balmaseda, A; Coelho, ICB; et al.	89
Combined detection and genotyping of Chikungunya virus by a specific reverse transcription-polymerase chain reaction	2002	Journal of Medical Virology	Hasebe, F; Parquet, MC; Pandey, BD; et al.	88
Open field release of genetically engineered sterile male Aedes aegypti in Malaysia	2012	PLOS One	Lacroix, R; McKemey, AR; Raduan, N; et al.	83
Rapid detection serotyping and quantitation of dengue viruses by TaqMan real-time one-step RT-PCR	2006	Journal of Virological Methods	Kong, YY; Thay, CH; Tin, TC; Devi, S	78
Antibodies against prM protein distinguish between previous infection with dengue and Japanese encephalitis viruses	2002	BMC Microbiology	Cardosa, MJ; Wang, SM; Sum, MSH; Tio, PH	77

Table 7. Highly cited Malaysian dengue-related journal articles as of October 2017

3.3. The relationship between the incidence of dengue fever and the number of scientific publications in Malaysia

Recorded dengue fever infection rates in Malaysia has increased from 376 infections in 1985 to 49355 infections in 2008 (Ministry of Health, 2011). The rise in dengue fever incidence from 2011 to 2012 was 10% (Maimusa et al. 2012, cited in Nurul Azam et al. 2016). The rate of publishing in Malaysia seems to match the rate of dengue fever, however (Figure 5).

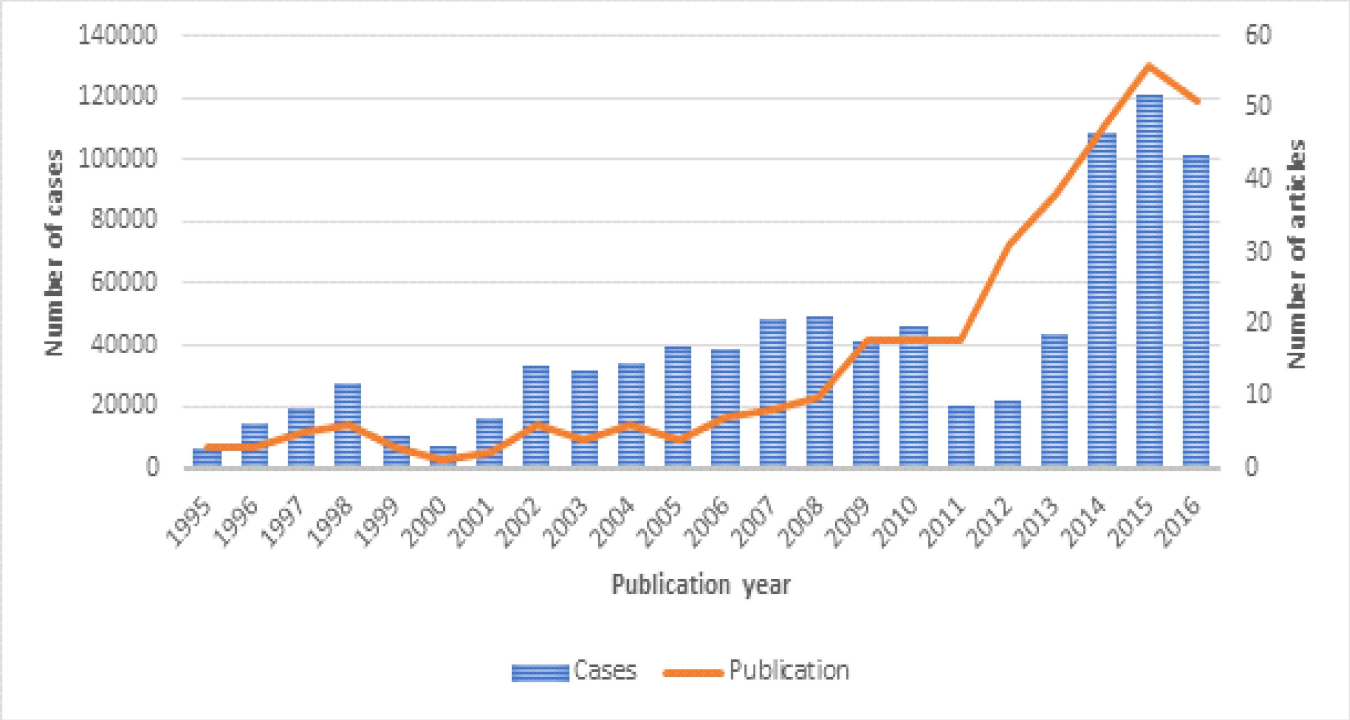

Figure 5. WoS dengue publications 1980-2017 internationally and the number or of reported cases in Malaysia.

4. Discussion

In response to the first research question, the results show that Malaysian dengue research forms a small fraction of the world's output. The total number of journal articles, 400 with PubMed IDs and an additional 138 without, is larger than the 100 (Ho, Siu & Chuang 2016) and 166 (Cheah et al. 2014) previously reported. Malaysian dengue research is almost always collaborative and frequently involves more than one institution and international collaboration, although the first author is usually Malaysian. It is published in a wide variety of national/regional and international journals from many different subject areas, although studies published in prominent international journals tend to be most cited.

For the second research question, Malaysian dengue research has been published in many different subject areas, but the main four topic areas are: virus biology; human infection; public health and mosquitos; and patients. These cover the main issues relevant to dengue fever. Nevertheless, the absence of Malaysia itself as a topic in the keyword map (Figure 4) is a concern given that public health aspects of a disease can have local concerns that need research. It is possible that this type of research has been conducted but published instead in non-academic formats, such as government reports. This would be reasonable, given that the priority is to inform public health decisions. A check of the search matches found that at least a third of them mentioned Malaysia, however (e.g., "Genetic polymorphism of Aedes albopictus population inferred from nd5 gene variabilities in Subang Jaya, Malaysia" and "Mosquito biology and mosquito-borne disease awareness among island communities in Malaysia", both in the Journal of the American Mosquito Control Association), suggesting that there is adequate nation-specific coverage, despite it not being reflected in the keyword map or subject classifications.

Addressing the third research question, the volume of dengue research from Malaysia has increased broadly in line with the recorded incidence of the disease. This may a coincidence, however, since academic research in Malaysia has also been increasing in volume during the same period so the results do not necessarily reflect an increased focus on dengue. The results also show that the previously-identified increasing volume of dengue-related journal articles (Zyoud 2016) has subsequently continued to occur.

5. Conclusion

This study has several limitations. Since WoS does not index all journals and has lower coverage of non-English journals, some Malaysian dengue research is likely to be missing. The biggest gaps are likely to be in the social sciences, where the coverage of WoS is weaker, and this probably applies most to the public health research topic. Another limitation is that whereas some of the articles analysed focused on aspects of dengue (e.g., "Localization of dengue virus in naturally infected human tissues"), others had a wider focus and mentioned dengue more peripherally, such as the highly cited article, "Isolation of subgenus B adenovirus…" which ruled dengue out as a cause of fatalities, and "Origin and Evolution of Japanese Encephalitis Virus in Southeast Asia", which discussed a different disease but contextualized the discussion by mentioning dengue and another virus as geographically co-occurring. Other articles may be omitted because they do not contain the term dengue even though they are relevant, for example by focusing on its vector mosquitos. Another limitation is that academic citations do not measure the public health or medical value of journal articles and so it is possible that the table of highly cited articles does not include the most influential publications, from a medical or public health perspective.

As a conclusion, this bibliometric study found rapidly increasing number of journal articles with a Malaysian author related to dengue fever. Reassuringly, these articles seem to cover all core issues related to the virus and the protection of public health, suggesting that Malaysia contains the academic expertise necessary to understand, advise and research about the disease. Given the widespread prevalence of dengue fever, however, it is important that this expertise is consulted by the government and health sectors to ensure that everything possible is being done to control the disease and support infected patients. Further study could be conducted to investigate impact of the research work through usage metrics and altmetrics indicators such as downloads, social media mentions, and Mendeley bookmarks since citations alone are insufficient to estimate overall research impact.

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References

[1] Al-Jabi SW. (2017). Global research trends in West Nile virus from 1943 to 2016: a bibliometric analysis. Global Health 2017;13:55. doi:10.1186/s12992-017-0284-y.

[2] Al-Jabi, S.W. (2017). Global research trends in West Nile virus from 1943 to 2016: A bibliometric analysis. Globalization and Health. DOI: 10.1186/s12992-017-0284-y.

[3] Arunachalam, S., Garg, K. C. (1985). A small country in a world of big science: A preliminary bibliometric study of science in Singapore. *Scientometrics*, 8, 301–313.

[4] Aswathy, S., Gopikuttan, A. (2013). Productivity pattern of universities in Kerala: a scientometric analysis. Annals of Library and Information Studies (ALIS), 60(3), 176-185.

[5] Baltussen, A., Kindler, C.H. (2004). Citation classics in anesthetic journals. Anesthesia and Analgesia, 98(2), 443–451.

[6] Belal, A.I.M., Shakeel, A.I.M. (2011). Emergence of dengue in Bangladesh a major international public health concern in recent years. *Journal of Environmental Research and Management.* 2 (3) 2020 035-041.

[7] Bhardwaj, R.K. (2014a): Dengue Fever: A bibliometric analysis of India's contributions to the research literature of this dangerous tropical disease. *Science & Technology Libraries*, 00, 1-13. DOI: 10.1080/0194262X.2014.943117.

[8] Bhardwaj, R.K. (2014b). Dengue research: A scientometric mapping of world publications. *SRELS Journal of Information Management,* 51 (2) 1-10.

[9] Bhatt, S., Gething P.W., Brady O.J., Messina, J.P., Farlow, A.W., Moyes C.L., et al. (2013). The global distribution and burden of dengue. *Nature,* 496(7446), 504-507.

[10] Brooke, B.S., Nathan, H., Pawlik, T.M. (2009). Trends in the quality of highly cited surgical research over the past 20 years. *Annals of Surgery,* 249 (1) 162–167.

[11] Bujang, M.A., Mudin, R.N., Haniff, J. et al (2017). Trend of dengue infection in Malaysia and the forecast up until year 2040. *International Medical Journal*, 24 (6) 438 – 441.

[12] Bundschuh, M., Groneberg, D., Klingelhoefer, D., Gerber, A. (2013). Yellow fe-ver disease: density equalizing mapping and gender analysis of international research output. Parasit Vector, 6, 331.

[13] Cheah, W.K., Ng, K.S., Marzilawati, A-R., Lum. L.C.S. (2014). A review of dengue research in Malaysia. *Med J Malaysia*,

69(Supplement A), 59-67.

[14] Chuang, K.Y., Wang, M.H., & Ho, Y.S. (2011). High-impact papers presented in the subject category of water resources in the Essential Science Indicators database of the Institute for Scientific Information. *Scientometrics*, 87 (3) 551–562.

[15] Cucunawangsih, X. & Lugito, N.P.H. (2017). Trends of dengue disease epidemiology. Virology: Research and Treatment, 8, 1-6. DOI: 10.1177/1178122X17695.

[16] Dhara, V. R., Schramm, P. J., Luber, G. (2013). Climate change & infectious diseases in India: Implications for health care providers. *The Indian Journal of Medical Research*, 138 (6) 847–52.

[17] Dutt, B., Kumar, S. & Garg, K.C. (2010). Scientometric profile of global dengue research, *Collnet Journal of Scientometrics and Information Management* 4 (1) 81–91.

[16] Griswold, M.G., Fullman, N., Hawley, C., Arian, N., Zimsen, S.R.M., et al. (2018) Alcohol use and burden for 195 countries and territories, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*, 392 (10152), 1015-1035. DOI:10.1016/S0140-6736(18), 31310-2

[17] Hagel, C., Weidemann, F., Gauch, S., Edwards, S. & Tinnemann, P. (2017) Analysing published global Ebola Virus Disease research using social network analysis. PLoS Negl Trop Dis 11 (10): e0005747. DOI: 10.1371/journal.pntd.0005747.

[18] Hanley K.A. & Weaver S.C. (2010). Frontiers in Dengue Virus Research. Norfolk: Caister Academic Press.

[19] Ho, Y-S. & Kahn, M. (2014). A bibliometric study of highly cited reviews in the science citation index expanded. *Journal of the Association For Information Science and Technology*, 65 (2) 372–385.

[20] Ho, Y-S., Siu, E., Chuang, K-Y. (2016). A bibliometric analysis of dengue-related publications in the Science Citation Index Expanded. *Future Virol*, 11(9) 631–648.

[21] Kementerian Kesehatan. Profil kesehatan Indonesia 2015 [Internet]. Kementerian. Kesehatan Republik Indonesia. 2015. Available from: http://www.depkes.go.id/resources/download/pusdatin/profil-kesehatanindonesia/profil-kesehatan-indonesia-2014.pdf.

[22] Krishnamoorthy, G., Ramakrishnan, J., Devi, S. (2009). Bibliometric Analysis of literature on diabetes (1995-2004). *Annals of Library and Information Studies,* 54 (September), 150-155.

[23] Lashley, F. (2007). Emerging infectious diseases, 2nd ed. New York: Springer.

[24] Liew, S.M., Khoo, E.M., Ho, B.K., Lee, Y.K., Omar, M., Ayadurai, V. et al. (2016). Dengue in Malaysia: factors associated with dengue mortality from a national registry. *PLoS ONE* 11 (6) e0157631. DOI:10.1371/journal.pone.0157631.

[25] Lipsman, N., Lozano, A.M. (2011). The most cited works in major depression: The 'citation classics.' *Journal of Affective* Disorders, 134 (1–3) 39–44.

[26] Lugova, H. & Wallis, S. (2017). Cross-sectional survey on the dengue knowledge, attitudes and preventive practices among students and staff of a public university in Malaysia. *Journal of Community Health* 42 (2) 413-420, DOI: 10.1007/s10900-016-0270-y.

[27] Maimusa, A.H., Jambari, H.A., Yahya, A.A.,& Ahmad, S.S. (2012). Aedes mosquitos' surveillance in non-residential areas in university campus in Malaysia. *Asian J Exp Biol Sci*, 3,163-139.

[28] Martinez-Pulgarin, D.F., Acevedo-Mendoza W.F., Cardona-Ospina J.A., Rodríguez-Morales A.J., Paniz-Mondolfi, A.E. (2016). A bibliometric analy-sis of global Zika research. *Travel Med Infect. Dis*,14 (1) 55-7.

[29] Maula, A.W., Fuad, A. & Utarini, A. (2018) Ten-years trend of dengue research in Indonesia and South-east Asian countries: a bibliometric analysis, *Global Health Action*, 11:1, 1504398, DOI: 10.1080/16549716.2018.1504398.

[30] McKenna, M. (2012). Dengue, aka "Breakbone Fever," is back. Slate. http://www.slate.com/articles/health_and_science/pandemics/2012/12/dengue_fever_in_united_states_breakbone_fever_outbreaks_florida_texas_and.html.

[31] Mia, M.S., Begum, R.A., Er, A.C. et al. (2013). Trends of dengue infections in Malaysia, 2000-2010. Asian Pac J Trop Med, 6, 462-466.

[32] Milojeviæ, S., & Leydesdorff, L. (2013). Information metrics (iMetrics): a research specialty with a socio-cognitive identity? *Scientometrics,* 95 (1) 141-157.

[33] Ministry of Health Malaysia (2010a). Clinical practice guidelines on management of dengue infection in adults. Revised 2nd ed Putrajaya, Malaysia: Ministry of Health.

[34] Ministry of Health Malaysia (2010b). Management of Dengue Infection in Adults. Revised 2nd ed. Putrajaya, Malaysia: Ministry of Health Malaysia.

[35] Mohd-Yajid, M.Z., Dom, N.C & Camalxaman, S.N. (2018). Research approaches on dengue surveillance in Malaysia from 2010-2016: A systematic review. Asia Pacific Environmental and Occupational Health Journal. 4(2).

[36] Morillo, F., Bordons, M. & Gomez, I. (2001). An approach to interdisciplinary through bibliometric indicators. Scientometrics. 51 (1) 203-22.

[38] Mota, F.B., Fonseca, B.P.F.E., Galina, A.C., & Silva, R.M.D. (2017). Mapping the dengue scientific landscape worldwide: a bibliometric and network analysis. Mem Inst Oswaldo Cruz, Rio de Janeiro, 112 (5) 354-363.

[39] Mudin, R.N. (2015). Dengue incidence and the prevention and control program in Malaysia. The International Medical *Journal Malaysia*, 14(1), 5-9.

[40] Muñoz-Urbano, M., López-Isaza A.F., Hurtado-Hurtado, N., Gómez-Suta, D., Murillo-Abadia, J., Delgado-Osorio, N., et al. (2014). Scientific research in malaria: bibliometric assessment of the Latin-American contri-butions. Recent Pat Antiinfect *Drug Discov.* 9 (3) 209-15.

[41] Murray, N.E.A., Quam, M.B. & Wilder-Smith, A. (2013). Epidemiology of dengue: past, present and future prospects. Clin *Epidemiol.* 5, 299-309.

[42] Nguyen, T.V., Pham, L.T. Scientific output and its relationship to knowledge economy: an analysis of ASEAN countries. *Scientometrics* 89, 107–117 (2011). https://doi.org/10.1007/s11192-011-0446-2

[43] Noruzi, A. & Abdekhoda, M. (2014). Scientometric analy-sis of Iraqi-Kurdistan universities' scientific produc-tivity. Electronic Library, 32 (6) 770-785.

[44] Nurul Azam, M., Yeasmin, M., Ahmed, N. U. & Chakraborty, H. (2016). Modeling Occurrence of Dengue Cases in Malaysia. *Iranian Journal of Public Health,* 45 (11) 1511–1512.

[45] Oo, P. M., Wai, K. T., Harries, A. D., Shewade, H. D., Oo, T., Thi, A., & Lin, Z. (2017). The burden of dengue, source reduction measures, and serotype patterns in Myanmar, 2011 to 2015-R2. Tropical medicine and health, 45, 35. DOI:10.1186/s41182-017-0074-5

[46] Ponce, F.A. & Lozano, A.M. (2011). The most citedworks in Parkinson's disease. Movement Disorders, 26(3), 380–390.

[47] Ramakrishnan, J. & Rajendran, P. (2004). Mapping the literature of Hepatitis B. In: Information and knowledge Management in Health Sciences: Newer Perspectives MLAI 2004 National Convention. Dr. ALM Post Graduate Institute of Basic Medical Sciences, University of Madras, Chennai, India, 216-224.

[48] Ramakrishnan, J. & Thavamani, K. (2012). Bibliometric analysis of the literature of Hepatitis C. In: Role of Medical Libraries in Global Health Initiatives MLAI 2012. National Convention. North Eastern Indira Gandhi Regional Institute of Health & Medical Sciences, Shilog, India.

[49] Ramesh Babu, B. & Ramakrishnan, J. (2010). Indian Contributions to the field of HIV/AIDS (1997-2006): A Scientometric Study. In: Webometrics, Infometrics and Scientometrics: Measuring Sceintific and Technological Progress of India. Ed by S.L. Sangam et al. Dharwad: Karnatak University,164-178.

[50] Ranjit, S. & N. Kissoon. (2011). Dengue hemorrhagic fever and shock syndromes. Pediatric Critical Care Medicine: A Journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies, 12(1), 90–100. DOI:10.1097/PCC.0b013e3181e911a7.

[51] Reidpath, D.D., Allotey, P. & Pokhrel, S. (2011). Social sciences research in neglected tropical diseases 2: A bibliographic analysis. Health Research Policy and Systems, 9 (1) 1-12. DOI:10.1186/1478-4505-9-1.

[52] Sam, J. (2008). An Analysis of Ghana Library Journal: A Bibliometric Study. African Journal of Library Archi-ves and Information Science, 18 (1) 55-62.

[53] Saquib, N., Zaghloul, M.S., Mazrou, A.R. & Saquib, J. (2017). Cardiovascular disease research in Saudi Arabia: a bibliometric analysis. Scientometrics. DOI: 10.1007/s11192-017-2393-z.

[54] Sulaiman, N.S. & Choy, E.A. (2016).Dengue control and prevention in Malaysia: a review of government involvement. Journal of Social Sciences and Humanities. 11 (2) 125-141.

[55] Vera-Polania, F, Muñoz-Urbano, M., Bañol-Giraldoo, A.M., Jimenez-Rincón, M., Granados-Álvarez, S., Rodriguez-Morales, A.J. (2015). Biblio-metric assessment of scientific production of literature on chi-kungunya. *J Infect Public Health.* 8(4), 386-388.

[56] WHO. (2009). Dengue. Guidelines for diag-nosis, treatment, prevention and control. Geneva: World Health Organization.

[57] WHO. (2012). Global Strategy for Dengue Prevention and Control 2012-2020. Geneva, Switzerland,1–43.

[58] WHO. (2017). Integrating neglected tropical diseases in global health and development fourth WHO report on neglected

tropical diseases. Available from: http://www.who.int/neglected_diseases/resources/9789241565448/en/.

[59] WHO-SEARO. (2011). Comprehensive guidelines for prevention and control of dengue and dengue haemorrhagic fever (Revised and expanded edition). India: World Health Organization Regional Office for South East Asia.

[60] Wohlin, C. (2005). Most cited journal reviews in software engineering. *Information and Software Technology*, 47(15) 955.

[61] Zunt, J.R., Kassebaum, N.J., Blake, N., Glennie, L., Wright, C., et al. (2018). Global, regional, and national burden of meningitis, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Neurol*. 17(12),1061-1082. DOI:10.1016/S1474-4422(18)30387-9

[62] Zyoud, S.H. (2016). Dengue research: a bibliometric analysis of worldwide and Arab publications during 1872–2015. *Virology Journal,* 13(78). DOI:10.1186/s12985-016-0534-2.