INTERNATIONAL MEDICAL RESEARCH JOURNAL

BIBLIOMETRIC ANALYSIS OF INSTITUTE FOR MEDICAL RESEARCH (IMR) PUBLICATION FOR THE YEAR 2000 TO 2019

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ABSTRACT

Bibliometric analysis of the Institute for Medical Research (IMR) measures the growth rate and impact of science research of the IMR. This is the first bibliometric analysis for IMR. This study analyzes the bibliometric characteristics of publications affiliated with the IMR. The focus is on publications from 2000 to 2019, to understand the growth rate and impact of scientific research conducted at the IMR. The data were sourced from the Scopus database. The relative growth rate, doubling time, collaborative index, and collaborate coefficient were conducted with Microsoft Excel, while the clustering analyses were conducted using VOSviewer software. From the year 2000 to 2019, IMR published a total of 1,244 articles with a total citation of 22,336. The increasing trend of publications, from 22 articles (the year 2000) to 128 articles (the year 2019) showed a steadily growing rate of 14 articles in the recent five years (the year 2015 to 2019). The collaboration coefficient of the authorship was 0.79, with Dr Lee Han Lim as the most prolific author (h-index of 27). The top keywords included clinical study, virus, Aedes, and plant leaf. The high collaboration coefficient of IMR indicated that 79% of the publications were contributed by multiple co-authorships, which is also a good sign of a collaboration network with other institutes, and universities from locally and internationally. The findings and publications of IMR will be the source of knowledge for future generations. IMR continues to serve as the research arm of the National Institutes of Health, Ministry of Health Malaysia.

KEYWORDS: Bibliometric, Authorship, Collaboration, Citation

INTRODUCTION

Bibliometric analysis is a branch of study that examines the performance of scientific publications in terms of author, affiliations, collaboration network, and publication year. The analysis is applied to describe the scientific performance of a journal, an institution, a study topic area, a notable researcher, or a new technology or knowledge. This is a measure of the growth rate and impact of science (Bornmann and Mutz 2015). Bibliometric research was traced to its first application, which was known as "statistical bibliography" by E. Wyndham Hulme in 1922 (Pritchard 1969). The "bibliometrics" was then suggested by Allan Pritchard in 1969, emphasizing on the application of mathematics and statistical methods to books and other media of communication. Henceforth, it was analogous to 'biometrics', 'econometrics', and 'scientometrics' (Pritchard 1969). The improving internet and database technologies serve as the main contributors for the bibliometric analysis to be widely applied as a tool to collect and measure the impact of publication works (Sharma and Mani 2009; Taşkın et al 2015).

Institute for Medical Research (IMR), Kuala Lumpur, Malaysia, was established in 1900 by Sir Frank Swettenham, Resident-General of the Federated Malay States. IMR is the research arm of the Ministry of Health, one of the six research institutes in the National Institutes of Health Malaysia. The main function of IMR is to carry out research to identify, elucidate, control, and prevent diseases and health issues prevalent in Malaysia. The research of IMR focused on Beri-Beri, malaria, scrub typhus, dysentery, cholera, typhoid, smallpox, leprosy, tuberculosis, dengue, filariasis, COVID-19, cancer, and traditional herbal medicinal plants. Besides, IMR also provides training in specialized fields, consultative/advisory services, and specialized diagnostic services. IMR is the WHO Regional Centre for Research and Training in Tropical Diseases and Nutrition, WHO Collaborating Centre for Ecology, Taxonomy, and Control of Vectors of Malaria, Filariasis and Dengue, INTROM Inter-Islamic Network on Tropical Medicine and SEAMEO-TROPMED Regional Centre for Microbiology, Parasitology and Entomology.

Sharma and Mani 2009 reported the bibliometric works on the Central Potato Research Institute from 1991 to 2007 by extracting 2603 research articles from annual reports and journals. The majority of the scientists published in joint authorship (82.79%) and two authorships were the highest (32.03%). The potato literature growth rates were estimated as 115.38% in 1993 and -47.43% in 2007. Taşkın et al (2015) discovered the collaborative multidisciplinary astrobiology research of the National Aeronautics and Space Administration (NASA) Astrobiology Institute on 1,210 research articles, where publishing in high-impact journals is preferred and in the category of Astronomy and Astrophysics. The most common journal to publish was "Astrophysical Journal" (13.3%). The most productive researchers originated from NASA, the Carnegie Institute of Washington (CIW), California Institute of Technology (CalTech), Pennsylvania State University, Arizona State University (ASU), and the University of Washington. SC Solomon (57) RP Butler (40) and P Ehrenfreund (33) were the most productive NAI-funded authors. The Tata Institute of Social Sciences of India indicated the collaboration coefficient of the 613 single-authored papers is 92.46% and Murli Desai published the highest number of papers (Koganuramath et al. 2002). Herbertz et al 1995 assessed the research performance of 13 research institutes in the field of molecular biology for a year (1980-1984) (1995) focusing on the citations per publication.

The bibliometric analysis on IMR has not been conducted, therefore this is the first bibliometric study on the scientific works of IMR. This study aims to analyze the bibliometric characteristics of publications affiliated with the Institute for Medical Research (IMR) spanning from the year 2000 to 2019. The focus is on the understanding of the growth rate and impact of scientific research conducted at the IMR. The specific objectives were, firstly to analyze the general publication trends, i.e. total publication, total citations, and relative growth rate of the articles published by IMR's researcher; secondly, to scrutinize the authors' profile, authorship trend, and their collaboration; thirdly, to determine the collaborative network of the keywords.

MATERIALS AND METHODS

Data Preparation

The data was sourced from the Scopus database on 1 March 2022. The export function was limited to 2000 records per download; hence the data was divided into two groups; 1927 documents that were published up to year 2016 and 436 documents from the year 2017 to 2022. We used the search term for the affiliation of "Institute for Medical Research Kuala Lumpur" (Affiliation ID=60030599) in the period from the year 2000 to the year 2019. The data was compiled to study various aspects of relative growth rate (RGR), doubling time (DT), collaboration index (CI), and collaboration coefficient (CC).

The collaboration coefficient (CC) was suggested by Ajiferuke et al. (1988) as listed below:

$$CC = 1 - \frac{\sum_{j=1}^{A} \left(\frac{1}{j}\right) fj}{N}$$

where,
j = the number of authors in an article i.e. 1, 2, 3 ……
fj = the number of j-authored articles
n = the total number of articles published in a year, and
a = the total number of authors per article

The author ID is a unique identifier for each author in Scopus. Hence, the author ID list was compiled in a CSV file and the occurrences were calculated by the Python panda package. The top twenty author IDs were then matched with the author's name in the Scopus. This procedure was to standardize the naming format and to avoid the duplication of the same author.

Data analysis

The VOSviewer was utilized to analyze the co-occurrences of the search term. The circle of an item and the size of the label varied by the weight of the item, where the higher the weight of an item, the larger the circle of the item and the label (Sajovic et al. 2018). The lines between items were determined by the links and strength of the items, while the color of an item represented the clusters. For the author analysis, the minimum number of documents for an author was 5, on the 4,931 authors, 378 meet the threshold and the largest set of connected items consists of 365 items. The author's analysis result was then saved as a map and network file. The authors' names were capitalized manually in the map file. When the saved map file was reopened in the VOSviewer, the authors' names were capitalized accordingly.

The keyword was analyzed based on the authors' keywords including column "title" and "index keywords" of the Scopus data. The keyword occurrences with more than one were set as the minimum value for the analysis. In VOSviewer, we selected the "create a map based on text data" to create a term co-occurrence map based on text data that was formatted in the .csv file. Next, we selected the fields from which terms will be extracted and this function was by default limited to fields "Title" and "Abstract" only. Hence, we manually changed the columns header of the Scopus .csv source file from "index keyword" to "abstract" to enable further analysis. The term then consisted of "Title" and "Abstract". To improve the understanding of the patterns of research terms across the 20-year study period, we analyzed them on a 5-year basis.

The Scopus provided author linkage service in which the one author with name variations was checked simultaneously. The trend of the subject area was extracted for the 20-year study period. The subject areas were pre-identified by the Scopus database in the search refine session. We extracted the top three authors' information for the top five subject areas of the articles.

RESULTS

Publication trend: numbers, citations, and relative growth rates

The affiliation "Institute for Medical Research Kuala Lumpur" (IMR) published 1,346 articles, with a total citation of 22,336 from the year 2000 to 2019. The number of publications showed an increasing trend for the 20 years, from 22 (1.96%) articles that were published in the year 2000 to the peak of 128 (10.05%) articles in the year 2019. The total citations depicted a cyclical pattern, with the first peak in the year 2005 of 1,682 citations and the highest peak in the year 2012, with the total citations of 2,589, extracted date on March 17, 2022 (Figure 1A).

The overall five-year relative growth rate (RGR) of the publications of IMR was 0.0406, with the first peak in the year 2005 (RGR=0.0506) and the second higher peak in 2012 (RGR=0.0645) (Figure 1B). Although the RGR dropped to 0.0465 in 2018, the recent years plausibly exhibited an upward trend to 0.0589 in the year 2019. The doubling time of publishing the articles showed a steady rate of 14 articles in the last five years.

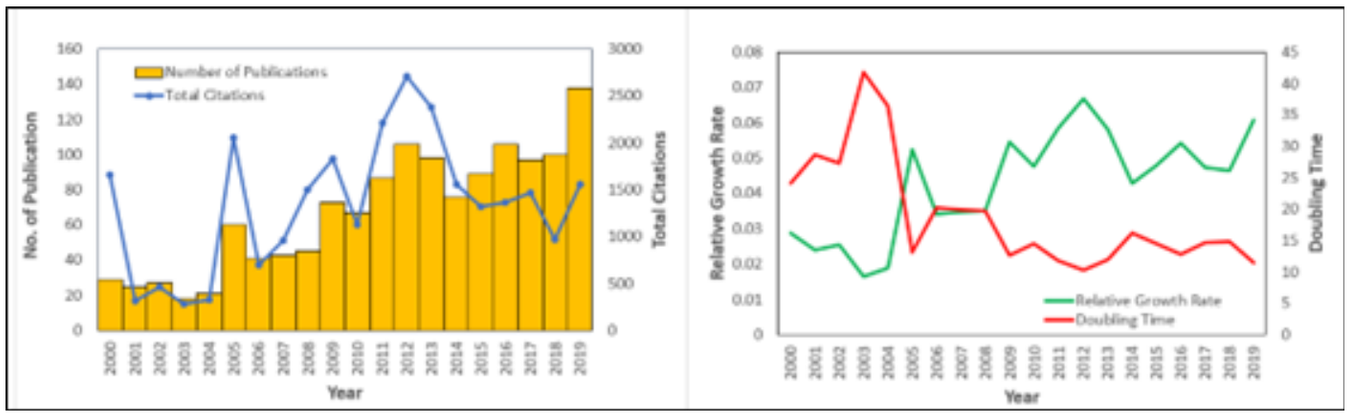

Figure 1. (A) Number of publications and total citations; (B) Relative growth rate and doubling time of the publications of IMR from the year 2000 to 2019

The top highest cited publication was the paper titled "Deaths of Children during an Outbreak of Hand, foot and Mouth Disease in Sarawak, Malaysia: Clinical and Pathological Characteristics of the Disease" by L. G. Chan et al. 2000 with 443 citations (Table 1). In the same year, an article titled "Chronic hepatitis B virus infection in Asian countries" by I. Merican et al. 2000 in the Journal of Gastroenterology and Hepatology obtained the second highest citation of 403. However, a publication with the title "Rising rural body-mass index is the main driver of the global obesity epidemic in adults" by NCD Risk Factor Collaboration (2019) obtained the highest total citations per year of 61.

Table 1. Top 10 most cited publications (Citations from Scopus)

No	Title (IMR's first authors in bold)	Journal	Total citation	Total Citation per year
1	Deaths of children during an outbreak of hand, foot, and mouth disease in Sarawak, Malaysia: Clinical and pathological characteristics of the disease (Chan et al. 2000)	Clinical Infectious Diseases	443	19
2	Chronic hepatitis B virus infection in Asian countries (Merican et al. 2000)	Journal of Gastroenterology and Hepatology (Australia)	403	18
3	Asian-Pacific Consensus Statement on the management of chronic hepatitis B: A 2005 update (Liaw et al. 2005)	Liver International	322	18
4	Efficacy and safety of lapatinib as first-line therapy for ErbB2-amplified locally advanced or metastatic breast cancer (Gomez et al. 2008)	Journal of Clinical Oncology	293	20
5	Changing trends in antimicrobial resistance and serotypes of Streptococcus pneumoniae isolates in Asian countries: An Asian Network for Surveillance of Resistant Pathogens (ANSORP) study (Kim et al. 2012)	Antimicrobial Agents and Chemotherapy	249	23
6	Rising rural body-mass index is the main driver of the global obesity epidemic in adults (NCD Risk Factor Collaboration 2019)	Nature	243	61
7	Successful suppression of a field mosquito population by sustained release of engineered male mosquitoes (Harris et al. 2012)	Nature Biotechnology	242	22
8	Refractive error and visual impairment in school-age children in Gombak District, Malaysia (Goh et al. 2005)	Ophthalmology	234	13

9	High prevalence of multidrug-resistant nonfermenters in hospital-acquired pneumonia in Asia (Chung et al. 2011)	American Journal of Respiratory and Critical Care Medicine	218	18
10	Genome-Wide Association Study in BRCA1 Mutation Carriers Identifies Novel Loci Associated with Breast and Ovarian Cancer Risk (Couch et al. 2013)	PLoS Genetics	204	20

The document type of the publication was in many forms; journal (1126), Review (62), letter (14), Conference paper (13), Note (12), Book series (9), Erratum (5), Editorial (2) and short survey (1). Only English publications were included in this study. The top eleven highest journals were Tropical Biomedicine (128), Southeast Asian Journal of Tropical Medicine and Public Health (88), Malaysian Journal of Pathology (33), Medical Journal of Malaysia (28), International Medical Journal (23), Plos One (19), Asian Pacific Journal of Cancer Prevention (15), Sains Malaysiana (14), BMC Complementary and Alternative Medicine (11), Genome Announcements (11), and Malaria Journal (11). IMR collaborated most with researchers from the United Kingdom (70 publications), Japan (58), the United States (48), Australia (47) and China (38).

Authors Profile: top authors and author collaboration network

The publications in IMR consisted of single-authored, dual-authored, and mega-authored types. Table 2 lists the authorship distribution of publications that were published during the study period. The highest number of 21 articles were published in the year 2013 by five authors, whereas the highest number of articles published by a single author were 3 articles in the years 2001 and 2002, two authors were 4 articles in the years 2006 and 2017, and three authors were 9 articles in the year 2017. The highest number of articles published by four authors was 18 in the year 2012. The collaboration coefficient of the authorship counted an average of 0.79; with the highest value of 0.84 in the year 2016 and the lowest value of 0.67 in the year 2002. The five-year average of the collaboration coefficient showed an increasing upward trend of 0.72, 0.79, 0.81, and 0.82, respectively.

Table 2. The collaboration coefficient (CC) of authors from year 2000 to 2019

Year	1 AP	2 AP	3 AP	4 AP	5 AP	6 AP	7 AP	8 AP	9 AP	10 AP	>10 AP	TOTAL	Collaboration Coefficient (CC)	Average CC
2000	2	1	1	6	1	3	2		1	2	3	24	0.73	
2001	3	1	2	2	8	3		1	1		1	25	0.68	0.72
2002	3	2	3	6		2	2	3		1	1	24	0.67	
2003	1	2	2	3	2	3	3	2			0	15	0.72	
2004		2	1	5	1	4	2			1	2	14	0.78	
2005	1	2	8	16	7	6	4	3	2	1	7	58	0.78	0.79
2006		4	5	7	10	9	4				2	40	0.77	
2007		2	4	5	8	5	2	1	3	4	5	39	0.81	
2008		3	3	5	7	6	3	5	2	2	6	41	0.81	
2009		2	4	11	12	11	9	4	5	4	5	65	0.81	
2010		3	7	8	11	9	10	9		1	4	62	0.80	0.81
2011	2	3	6	16	12	5	9	9	1	5	12	78	0.79	
2012		2	7	18	16	18	9	6	5	2	16	101	0.82	
2013		1	4	7	21	13	10	11	5	5	12	93	0.83	
2014		3	2	9	11	13	9	8	1	2	14	78	0.83	
2015	1	1	4	16	13	16	8	6	3	1	11	82	0.81	0.82
2016		1	7	13	12	15	7	13	9	6	15	93	0.84	
2017		4	9	12	7	8	10	11	14	7	9	89	0.82	
2018		2	6	9	14	15	10	11	11	5	13	80	0.83	
2019	1	2	6	15	17	20	18	19	8	5	17	123	0.83	
Total/ Average	**14**	**43**	**91**	**189**	**190**	**184**	**131**	**122**	**71**	**54**	**155**	**1224**	**0.79**	

Note: AP - Authored Paper

Table 3 shows the top 10 authors in IMR who published 1,074 (10.84%) of the total output with total citations of 37,778 in the two decades. This is based on the analysis of author ID, which yielded 5,028 unique authors. For the 20 years study period, the most prolific author was Lee Han Lim from the Medical Entomology Unit, IMR, who published the most articles (148, 1.5%), which have been cited 2,877 times with (h-index=27) and CPP of 15. Nazni Wasi Ahmad, also the entomologist of the Medical Entomology Unit, IMR, ranked the second prolific author (94 articles, 0.95%) with 1,763 citations and 14 CPP (h-index=24). Norazah Ahmad, head of the Infectious Disease Research Centre, published 75 articles (0.76%) with total citations of 1,306 and 10 CPP (h-index=19). Among the top 22 authors, the works of Wan Nazaimoon Wan Mohamud from IMR obtained the highest total citations of 10,593 and the highest CPP of 151 for (h-index=30).

Table 3. Authors' total publications, citations, CPP and h-index

No	Author Name	Affiliations	No. of publications (2000-2019) (%)	No of citations	Citation per paper (CPP)	h-index
1	Lee H.L.	IMR	148 (1.5)	2,877	15	27
2	Nazni W.A.	IMR	94 (0.95)	1,763	14	24
3	Ahmad N.	IMR	75 (0.76)	1,306	10	19
4	Khoo A.S.B.	IMR	61 (0.62)	1,909	24	22
5	Sofian-Azirun M.	IMR, UM	60 (0.61)	2,347	12	26
6	Zakaria Z.	IMR	56 (0.57)	1,047	15	19
7	Chen C.D.	IMR, UM	51 (0.52)	1,128	11	19
8	Lim K.H.	IMR	48 (0.49)	984	12	18
9	Murad S.	IMR	47 (0.48)	1,399	22	22
10	Kee C.C.	IMR	46 (0.47)	1,094	16	19

Note: UM - Universiti of Malaya, IMR - Institute for Medical Research

Figure 2 shows the author's collaboration network from the year 2000 to 2019. The most productive authors were Lee H.L. (148 publications), Nazni W.A. (94), Ahmad N. (75), and Khoo A.S.B. (61), and they were in the same collaboration network. Whilst the authors Ng KH, Agatsuma T, and Lai PF published articles with their dedicated collaborators apart from the main cluster at the center (Figure 2). The lighter color yellow represented the recent year's authors' collaboration than the darker color purple.

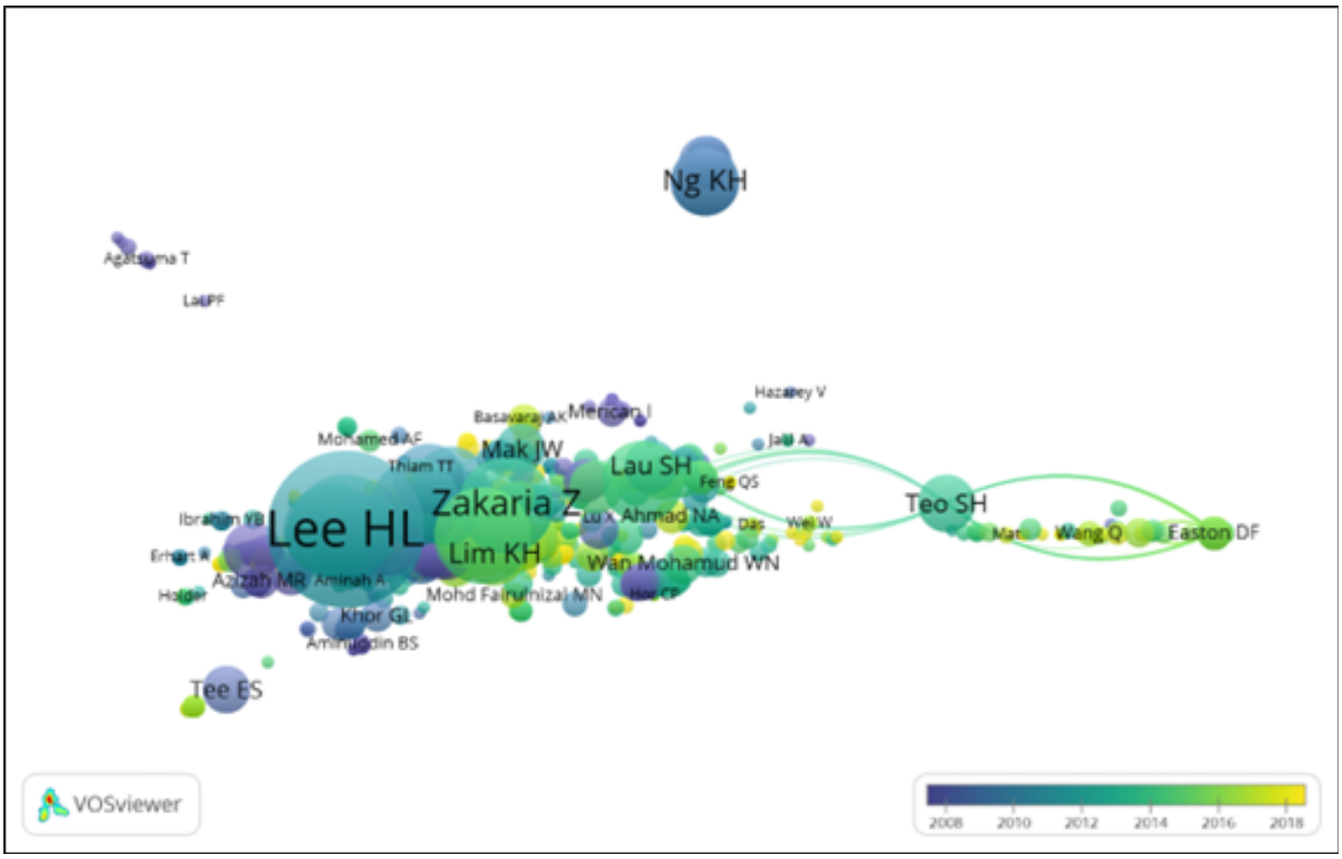

Figure 2. Author collaboration network of IMR's publications in the years 2000 to 2019

Keyword Profile: Network Collaboration and Subject Area

The keyword network mapping showed an increase in total keyword terms in the publication of IMR across the years, from 1,562 in the initial five years to 5,869 in the years 2015 to 2019 (Figure 3). From the year 2000 to 2005, the common terms that were in title and index keywords included "acid" (28 occurrences), "resistance" (14), "Asia" (12), and "DNA fingerprinting" (11). In the next five years from 2006 to 2009, "resistance" ranked highest with 33 occurrences, followed by "control" (24), "antigen" (24), "Aedes albopictus" (21), "aegypti" (19) and "expression" (19). From the year 2010 to 2014, articles on "drugs" topped the occurrences list with 73, which was doubled the second highest occurrence of "aedes" (48), followed by "cytochrome" (40), "virus" (28), "streptococcus pneumonia" (20), "plant extract" (20). Nevertheless, in the recent five years from 2015 to 2019, the top keywords were "clinical study" (58), "virus" (50), "aedes" (47), "plant leaf" (24), "candida" (18), and "diptera" (16). Table 4 shows the interlinking of the subject area and the top authors in the respective area.

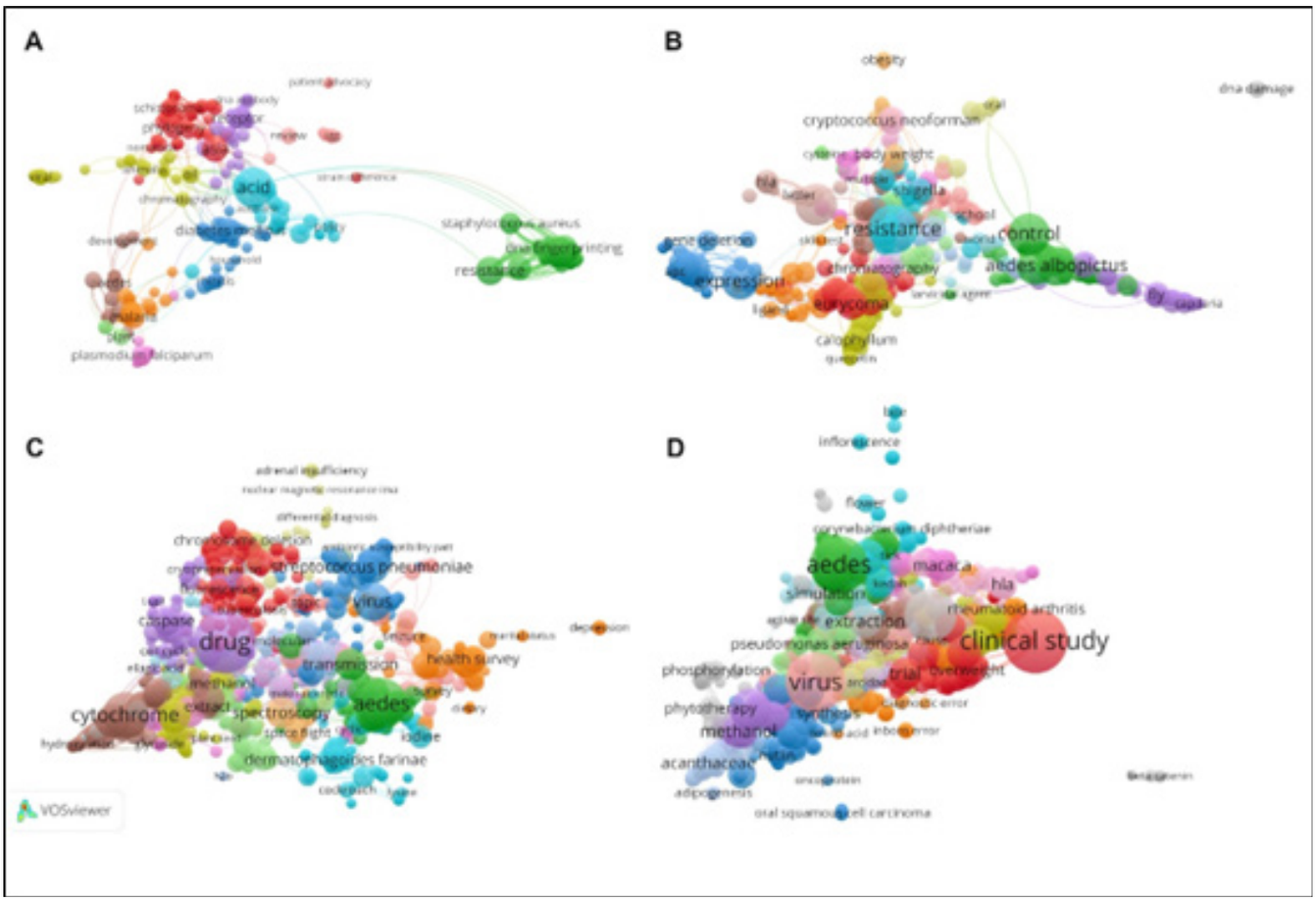

Figure 3. Keywords of IMR's publications in the years (A) 2000 to 2004; (B) 2005 to 2009; (C) 2010 to 2014; and (D) 2015 to 2019

Table 4. Subject area

No	Subject area	No. of articles	Top Authors
1	Medicine	1705	Lee, H.L. (97), Mak, J.W. (73), Nazni, W.A. (63)
2	Immunology and Microbiology	654	Lee, H.L. (82), Nazni, W.A. (51); Mak, J.W. (43),
3	Biochemistry, Genetics and Molecular Biology	470	Zakaria, Z. (39), Khoo, A.S.B. (33), Wan Nazaimoon W.M. (24)
4	Agricultural and Biological Sciences	296	Lee, H.L. (26); Mak, J.W. (20); Nazni, W.A. (20)
5	Multidisciplinary	100	Khoo, A.S.B. (6); Lee, H.L. (7); Nazni, W.A. (7)

The majority of the publications were about medicine (1705, 52.87%), immunology and microbiology (654, 20.28%), and biochemistry, genetics and molecular biology (470, 14.57%). The top authors did not limit themselves to one subject area, but multiple and diverse, i.e. Lee, H. L. published in the subject area of medicine, immunology and microbiology, and agricultural and biological sciences as well as multidisciplinary.

DISCUSSION

IMR, with more than 800 research officers, medical officers, and support staff, focuses on providing research and diagnostic services, especially in the national priority area of health problems such as non-communicable diseases and communicable diseases. The study concluded that IMR's publication showed an increasing trend from the year 2000 to 2019, which indicated a good milestone in the research performance of IMR throughout the years. IMR was established in 1900 by Sir Frank Athelstane Swettenham with the initial research focus on beri-beri and Malaria. To date, IMR's research extends to various diseases according to the current health priorities. The RGR, or the rate of accumulation of new publication per unit of existing publication, implied that the rate of author affiliated with IMR writing their articles. Whereas doubling time means how many times are required just to double the existing quantity with a given growth rate.

In general, the publication trends of IMR were measured in various forms, number of publications, and citations. The citation is a measure of the impact or the international visibility of the research (Van et al 2002). The citation analysis is sensitive and controversial in different disciplines due to the spectrum of document types, time since published, etc. (Glänzel et al. 1999) especially in medical research. Our study informed that the top two articles that received highest total number of citations were Chan et al. (2000), published in Clinical Infectious Diseases on the outbreak of hand, foot, and mouth disease with 29 deaths of children caused primarily by enterovirus 71 (EV71) in Sarawak, Malaysia and Merican et al. (2000), published in Journal of Gastroenterology and Hepatology on the current situation of chronic hepatitis B virus infection in Asian countries. Although the two articles yielded the highest total citations, the article NCD Risk Factor Collaboration (2019) showed a greater impact as its average citations per year was triple higher even was only published recently. The article NCD Risk Factor Collaboration (2019), published in Nature, discovered that the higher obesity was due to the rising Body-mass index (BMI) in rural areas which was contrary to the dominant paradigm that urbanization played a main role in contributing to rising BMI. Furthermore, this might be due to the "snowball effect" that people tend to cite articles that are already highly cited, in higher impact factors journals (Kuhn 1962).

The high collaboration coefficient of IMR (0.79) indicated that 79% of the publications were due to multiple co-authorship rather than single authorship. This is higher than the collaboration coefficient of the Tehran University of Medical Sciences (0.64) (Mardani et al. 2013) and lower than the University of Zambia (0.91) (Akakandelwa 2009). The publications that yielded a high number of citations were the research outputs of the international collaboration. The collaboration network of IMR is extensive and not limited to the local research institutes/ educational institutes but also extended to various international industrial partners and education/health research institutes. IMR served as the SEAMEO National Centre for Tropical Medicine since 1967 and in 1993, was redesignated as the SEAMEO TROPMED Regional Centre for Microbiology, Parasitology and Entomology. IMR also continues to serve as the WHO Collaborating Centre for (1) Taxonomy, Immunology, and Chemotherapy of Brugian Filariasis since 1981 (Division of Parasitology); and (2) Ecology, Taxonomy, and Control of Vectors of Malaria, Filariasis, and Dengue (since 1986) (Division of Medical Entomology). Three divisions of the Institute continue to serve as collaborating centers of WHO: (3) Division of Bacteriology as the national focal point for the WHO Collaborative surveillance program on antibiotic resistance in the Western Pacific Region and (4) Division of Virology as the WHO National Influenza Centre and the National Reference Laboratory for Polio Eradication and (5) INTROM, Secretariat for Inter-Islamic Network on Tropical Biomedicine. IMR also offered post-graduate courses in Diploma in Applied Parasitology and Entomology (DAP&E) Courses with candidates from Cambodia, Indonesia, Lao PDF, Malaysia, Oman, Papua New Guinea, Philippines, Solomon Islands, Thailand and Vietnam, Morocco, Kyrgyzstan, Bangladesh, and Diploma in Medical Microbiology (DMM) Course with the candidates from Cambodia, Myanmar, Pakistan, Philippines, South Africa, Thailand, Zambia, Vietnam and Lao PDR and Malaysia, Krygystan, Sultanate of Oman, Yemen, Bangladesh. Therefore, the research collaboration network was extended to many countries.

The valuable resources of IMR, the scientists and researchers, are well-trained in various expert areas. For 20 years, the most productive scientist are Lee. H.L. (148 papers), Nazni W.A. (94 papers), and Ahmad N. (75 papers). They were experts in medical entomology and medical microbiology. In addition to publications, IMR scientists also won many awards and recognition for their research outputs. The selected awards and recognition included the Gold Medal Award won by Dr Lee Han Lim at the 30th International Invention, Innovation & Products 2002 in Switzerland. Dr Lim Boo Liat was awarded an Honorary Membership to the American Society of Mammalogists in 2003, Spallanzani

Award in 2007, and Merdeka Award in 2013. In 2018, the IMR research team led by Dr. Nazni Wasi Ahmad won the Dr. LEE Jong-Wook Memorial Prize for Public Health at the Seventy-First World Health Assembly for their exemplary contributions to Maggot Debridement Therapy (MDT) for natural wound treatment using local fly Lucilia cuprica. In 2000, the commercialization products included MOSBAC, an aqueous suspension formulation containing the spore crystal complex of Bacillus thuringiensis; IMR-BT-1 for the biological control of mosquito larvae; R-EST, a test kit for the rapid detection of insecticide resistance; Nutri-Cal, a nutrient analysis and food composition data management software. The author's collaborative network of IMR increased over the years implying that research publication is an effort of collaboration among scientists. The total citations yielded by Wan Nazaimoon was higher asserting that her publications had a higher impact and drew the attention of the other experts and peer reviewers in her field, endocrinology, and biology focusing on Adipose Tissue, estrogens, endocrinology, diabetes, metabolism, diabetes mellitus and insulin. The size of the clustering networking of authors (Lee HL) showed that he had the most scientific papers in collaboration with other researchers in Malaysia or abroad, his collaboration mainly focused on medical entomology which encompassed how to reduce the dengue and dengue hemorrhagic fever which is among the diseases which is a burden to Malaysia population throughout the period 2012-1026, while Zakaria Z showed an increase in collaboration and publication after 2016. The study also found that authors such as Ng KH and Tee ES were also active in collaborating and publishing significant scientific articles at the beginning of 2010 in the field of stomatology and human nutrition.

The study on the subject areas revealed that the same top scholars published in mixed subject areas, e.g. Lee, H. L, Mak, J. W., Nazni, W. A. conducted research that is related to Medicine, Immunology and Microbiology, and Agricultural and Biological Sciences. These results indicated that prominent scientists do not limit their knowledge to one specialized area, but apply to different subject areas. The research problems are often extended across different subject areas. In other words, collaboration from experts in different subject areas is highly important for producing significant good research outputs.

The studies on keywords change over time according to the current disease outbreak and research priorities in Malaysia. Across the years, the number of research keywords increased fivefold. From the year 2000 to 2004, the research publications focused on antibiotics (chloramphenicol, tetracycline), drugs (methicillin, cotrimoxazole), drug resistance, malaria, and parasites. In the following years, research publications shifted to antigen, dengue vectors, gene expression and mutation, Eurycoma plants, and spectrometry. The publications on clinical study increased especially during the year 2015 to 2019. This is in line with the health problem faced by the Malaysian population and the research required to enable the decision is based on evidence-based medicine IMR is the institute that assisted the Ministry of Health toward that and this is highlighted through publication keywords, i.e. Research on vector-borne diseases has shifted from malaria control from 2000-2004 to studies that focus more on Aedes throughout the period from 2006 to 2019, while the study of mosquito resistance to pesticides was actively conducted throughout the years 2000-2009. After 2010, IMR studies shifted to the molecular field as stated in the keyword throughout this period. Between 2015 and 2019, the keywords Virus are among the keywords that are often used by IMR in scientific publications. This shows that viral diseases are among the diseases faced by the Malaysian population. Changes in keywords throughout 2000-2019 show the evolution of IMR studies in parallel with national health problems and technological advances in the molecular field and researchers at IMR The keywords analysis showed that the diversified IMR researchers, and they actively published research outcome for the reference by scientists in the country and abroad, as well as actively contributing to the body of knowledge in each discipline.

In this case, the organization structure underwent a transition from the existing five departments (the year 2000): Department of Tropical Medicine, Department of Clinical Pathology, Department of Community Medicine, Department of Support Services and Administration to the current structure of eight centers: Cancer Research Centre, Nutrition, Metabolic & Cardiovascular Research Centre, Herbal Medicine Research Centre, Infectious Disease Research Centre, Special Resource Centre, Environmental Health Research Centre, Allergy & Immunology Research Centre and Specialised Diagnostic Centre. This is in line with the change of research keywords to larger extents.

CONCLUSION

In conclusion, the bibliometric analysis is the measurement/milestone of the research activities. The general description trend, the most influential articles, the most prolific authors, the most important sources, and the collaboration networks are described and analyzed. IMR continues to serve as the research arm for the National Institutes of Health, Ministry of Health Malaysia. IMR's researchers continue to research the top priorities of public health problems in the country. The findings and publications of IMR will be the source of knowledge for future generations.

ACKNOWLEDGEMENTS

We would like to thank the Director General of Health Malaysia and the director of, the Institute for Medical Research (IMR) for their permission to publish this article. This work was accomplished under the project of the National Institute of Health, Ministry of Health Malaysia (NMRR-21-764-59478).

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