Evaluating the growth pattern and relative performance in *Nipah virus* research from 1999 to 2010

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ABSTRACT

The study examines Nipah virus publications retrieved from SCI-Expanded and SSCI database (Web of Science) for the period 1999–2010. Performance indicators used are: total publications, total citations, the activity index, the attractive index and the publication efficiency index. Yearly publication and citation trends indicated an exponential growth. The most active countries involved are USA, Australia, Malaysia, France, Germany and the UK. The USA produced the most papers, has the highest average citations per article and highest h-index. Australia is the most productive country based on per capita followed by Malaysia. The relative citation impact in Nipah virus research by these countries surpassed the world's average. The most active institutions are the Commonwealth Scientific and Industrial Research Organization, Australia (18.73%); Center for Disease Control and Prevention, USA (14.94%); and University of Malaya, Malaysia (12.41%).

Keywords: Nipah virus; Virology; Infectious diseases; Bibliometrics; Relative indicators.

INTRODUCTION

One way of highlighting contributions to scientific development is by studying the literature of a discipline as this can reveal emergence of new breakthrough in modern scientific and technological research (Chen and Guan 2011). Literature provides useful perspectives on the development and research performance of a field (Glänzel 2012; Moed and de Bruin 1990; Hu and Rousseau 2009) and the state of science in a particular country (Zhou and Leydesdorff 2006; Schmoch 2011; Schneider et al. 2010; Hammouti 2010; Jacobs and Pichappan 2001). The last two decades saw the emergence of a series of viral diseases. On this list is *Nipah virus,* a member of the family *Paramyxoviridae,* which is related but not identical to the *Hendra virus* (Yob et al. 2001) (*Hendra virus* was first isolated in 1994 in Hendra, a suburb of Brisbane, Australia). *Nipah virus* was isolated in 1999 upon examining samples from an outbreak of encephalitis and respiratory illness among adult men in Malaysia and Singapore (CDC 1999). There have been outbreaks reported in Bangladesh and India (Luby et al. 2006), Thailand (Wacharapluesadee et al. 2005), Cambodia(Reynes et al. 2005), Ghana and Madagascar (Kugler 2004; Chong, Abdullah and Tan 2009). Research on new strategies to inhibit the diseases has spread to other parts of world (Porotto et al. 2010). This virus is widespread in Southeast Asia (Olson et al. 2002) and may be less known in the field of virology but it is still very relevant to tropical countries in the Asia Pacific

region. In this paper we examine the growth and spread of *Nipah virus* literature in the Web of Science (WoS SCI-E and SSCI) databases during 1999-2010.

OBJECTIVES AND METHODS

This study examines *Nipah virus* literature published between 1999 and 2010, retrieved from the WoS (SCI-E and SSCI) databases. Performance indicators used include identifyingthe active countries, institutions, patterns of international collaboration and the analysis of publication activity and citation impact (Glänzel 2012). The main objectives are: to examine the trends and growth of *Nipah virus* literature; to measure and compare the performance of top countries in *Nipah virus* research; and to map institutional collaborations and co-citation network in *Nipah virus* publications. The query for "*Nipah virus*" was refined to include only original articles and review papers. The data set was cleaned of inconsistencies observed in the naming of affiliations and sources. Subsequently, the data from WoS were exported to BibExcel tool-box (Persson, Danell and Schneider 2009) to generate the growth trend, distribution of publications across countries, institutional productivity, and institutional collaboration pattern. We applied two relative indicators: the activity index (AI) and the attractive index (AAI) that have been described and used (Chen and Guan 2011; Hu and Rousseau 2009) to evaluate the structure of a country's contribution and the relative impact of research outputs of each country compared to the world's performance in a particular field. Likewise, we employed the publication efficiency index (PEI) described by Chen and Guan (2011) to determine if the impact of publications produced by a given country is significantly related to the research effort. To map institutional activity and collaboration, we employed Pajek network analysis software (Kamada and Kawai 1989) with its Kamada-kawai algorithm function (Falagas, Karavasiou and Bliziotis 2006) to generate network graphs. Our study is limited by the dataset obtained from WoS.

RESULTS

Overall Growth of *Nipah virus* Publications
The total number of publications in Web of Science (WoS) database was 426 publications with a yearly average of 35.5 papers. The growth of research publications is incremental (Figure 1).

During the period studied, the exponential growth pattern is reflected by the value of R^2 from Web of Science ($R^2 = 0.881$). This confirms the fast growth of publications produced in *Nipah virus* during 1999 - 2010. The total number of citations received by *Nipah virus* publications during 1999 – 2010 was 10572. The results indicate that while total number of publications is projected to increase, the number of citations that are being garnered is steadily declining, indicating a possible loss of interest in *Nipah Virus* research or that research in this area has matured.
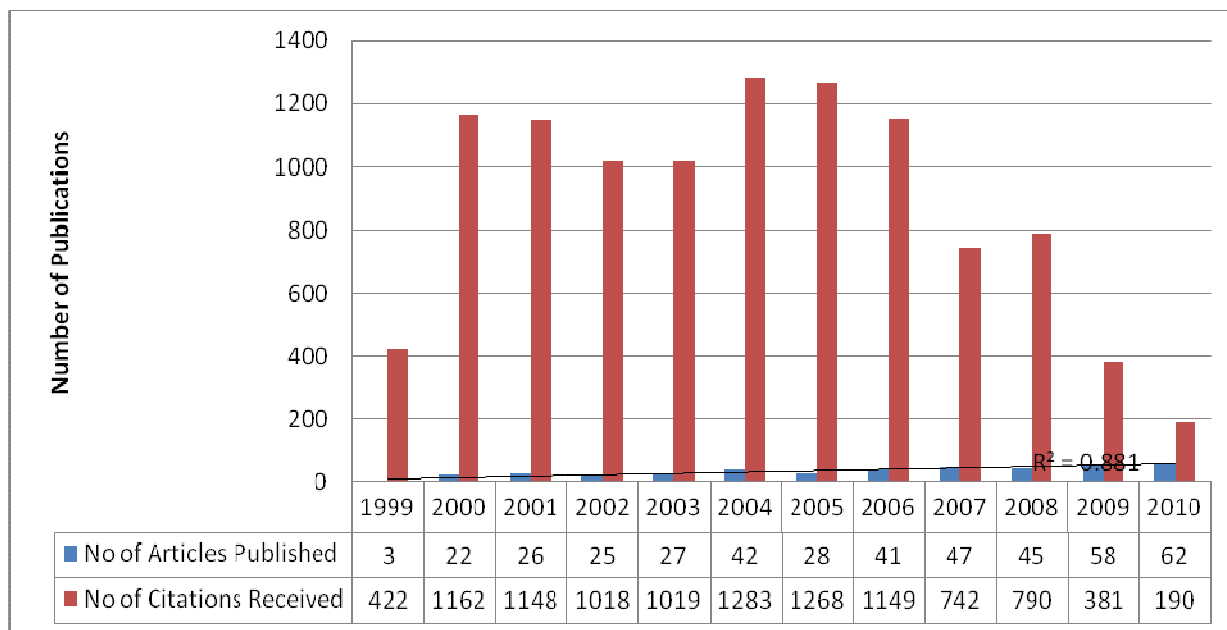
Figure 1: Publications and Citations in *Nipah Virus* (1999-2010).
Source: Web of Science (SCI-E and SSCI)

Performance of the Top-six Countries

The total number of articles produced during the period under study is 426 papers. However, the total number of contributions examined based on country is 635, since an article can be written by more than one author who may be affiliates of different countries. Table 1 shows the cross-country comparison amongst the top six contributing countries in *Nipah virus* during 1999-2010.

Table 1: Performance of the Top-six Countries in *Nipah virus* Research (1999 - 2010)

	Country	Publications	Total citations	Av. citations per article	Population (millions)	Publications per million	h-index	Income category
1	USA	222	7 959	35.85	313.4	0.71	49	High
2	AUSTRALIA	103	3 572	34.68	22.8	4.52	29	High
3	MALAYSIA	84	2 823	33.61	28.3	2.97	26	Uppermiddle
4	FRANCE	29	695	23.97	65.3	0.44	14	High
5	GERMANY	26	465	17.88	81.8	0.32	12	High
6	UK	22	877	39.86	52.2	0.42	12	High

The top active six countries are the, USA, Australia, Malaysia, France, Germany and UK. These 6 countries are involved in the production of 486 papers amounting to 76.5% of total articles counted for all countries during 1999-2010. The USA is involved in the production of one third of the overall papers and has the highest average citations per article (35.85 citations), followed by Australia (34.68 citations) (Table 1). Noteworthy is the contribution of Malaysia and Australia which were both affected by this tropical disease. Falagas, Karavasiou and Bliziotis (2006) observed that the developing areas of the world produce a considerable amount of research in tropical medicine during 1995 -2003 due to the specific

geographic distribution of tropical diseases. Australia is the most productive country per capita followed by Malaysia (Table 1). The population for each country was obtained from the United Nation population statistics 2011 (United Nation 2011) while the income category was obtained from the World Bank report (World Bank 2012). The USA has the highest h-index (Hirsch 2005), followed by Australia and Malaysia. This means that 49 publications out of the 222 publications by the USA during 1999 – 2010 have been cited at least 49 times. The h-index is useful because it discounts the disproportionate weight of highly cited papers or papers that have not yet been cited. Additionally, we observed the impact relationship between economic development and academic productivity, with higher income nations (except Malaysia) more likely to contribute to scientific research.

Activity Index (AI)

The activity index (AI) is an indicator, which compares a country's research performance with that of the world (Chen and Guan 2011; Hu and Rousseau 2009). The activity index is a relative performance indictor, which takes into account the effect of the publication size of the evaluated country in the *Nipah virus* literature.

Mathematically, the activity index (AIti) for the *i*th country in the *t*th year during the given period can be defined as follows:

$$AI^t_i = \frac{(P^t_i / \sum P)}{(TP^t / \sum TP)}$$

Pti is the *Nipah virus* publication by the *i*th country in the *t*th year; $\sum P$ is the *Nipah virus* publications by the *i*th country during the given publication period; *TPt* is the total *Nipah virus* publications by the world in the *t*th year; $\sum TP$ is the total *Nipah virus* publications by the world during the given publication period. If AI=1, it indicates that the country's research effort in a particular field corresponds precisely to the world's average. If AI>1, it can be said that the country spends more energy and money to the given field than the world average, or if AI<1, this reflects a specialization by this country in the field under study (Hu and Rousseau 2009; Chen and Guan 2011). Table 2 shows the AI scores of the top-six countries during 1999–2010.

Table 2: Activity index (AI) of Top Countries Researching on *Nipah virus*

Year	USA	Australia	Malaysia	France	Germany	UK
2010	1.08	0.60	0.49	0.47	1.05	1.87
2009	0.86	1.00	1.13	2.02	1.41	0.67
2008	1.06	1.05	0.43	0.31	1.74	1.23
2007	1.06	1.65	0.79	0.98	0.36	0.00
2006	1.05	0.79	0.60	2.09	0.39	0.46
2005	0.70	0.70	0.37	0.36	1.59	0.00
2004	1.42	0.92	1.87	2.17	3.03	2.86
2003	1.06	0.61	1.31	1.63	0.00	2.15
2002	0.88	1.11	1.95	0.56	0.00	0.00
2001	1.23	2.31	2.23	0.00	0.00	1.55
2000	0.61	0.75	1.61	0.00	0.74	0.88
1999	0.17	0.00	0.22	0.00	0.00	0.00
Mean	0.93	0.96	1.08	0.88	0.86	0.97

The USA has produced the most publications on *Nipah virus*. Malaysia has the highest mean AI score (1.08) during 1999-2010, which means that Malaysian contribution to this research is more than the world's average, indicating an active and specialized focus. Consequently, the *Nipah virus* Investigation Team at the Faculty of Medicine, University of Malaya was awarded with the prestigious Malaysian Independence Award in 2008 for their contribution to the disease. Malaysia's recent performance has decreased especially from 2005 to 2008. Malaysia's performance picked up by year 2009 (AI>1) but performed below world average in year 2010. Germany, despite a late start, was active in *Nipah virus* research in the later years especially between 2008 and 2010.

Attractive Index (AAI)

The attractive index (AAI) is an indicator that is used to characterize the relative impact of a country's publications in a given field as reflected by the citations they received during a given period (Chen and Guan 2011; Hu and Rousseau 2009). Mathematically, the attractive index (AAIti) for the ith country in the tth year during the given period can be defined as follows:

$$AAI^t_i = \frac{(C^t_i / \sum C)}{(TC^t / \sum TC)}$$

Cti is the *Nipah virus* citations by the ith country in the tth year; ∑C is the *Nipah virus* citations by the ith country during the given citation period; TCt is the total *Nipah virus* citations by the world in the tth year; ∑TC is the total *Nipah virus* citations by the world during the given citation period. If AAI=1, indicates that the country's relative citation impact in the given field corresponds precisely to the world average. If AAI >1, indicates that the country's relative citation impact in that field is higher than the world average and if AAI<1, indicates that the country's relative citation impact in the field is lower than the world average(Hu and Rousseau 2009; Chen and Guan 2011). Table 3 shows the AAI scores for the top-six contributing countries during 1999–2010.

Table 3: Attractive index (AAI) of Top Countries Researching on *Nipah virus*

Year	USA	Australia	Malaysia	France	Germany	UK
2010	1.46	1.35	1.00	1.78	2.08	1.58
2009	1.46	1.34	1.11	1.53	1.98	1.46
2008	1.50	1.51	1.16	1.43	1.41	1.47
2007	1.47	1.56	1.33	1.53	1.57	1.37
2006	1.43	1.54	1.51	1.77	1.44	1.38
2005	1.42	1.38	1.69	1.98	1.31	1.57
2004	1.34	1.63	2.14	0.82	0.00	1.88
2003	1.23	1.22	2.63	0.31	0.00	1.27
2002	1.29	1.78	3.11	0.18	0.00	0.73
2001	1.43	1.68	3.00	0.00	0.00	0.67
2000	1.58	0.96	3.04	0.00	0.00	0.25
1999	2.10	0.00	2.68	-	-	-
Mean	1.48	1.33	2.03	1.03	0.89	1.24

Apart from Germany, all the other countries recorded attractive index greater than 1 (AAI>1) during 1999-2010. This means that the relative citation impact in *Nipah virus* research obtained by the USA, Australia, Malaysia, France and UK surpass the world's

average. However, Germany seems to be performing better than other countries in the recent years (during 2009 and 2010).

Publication Efficiency Index (PEI)

The publication efficiency index (PEI) is an indicator that determines if the impact of research publications by the top-six contributing countries in *Nipah virus* corresponds with the country's research efforts during the period 1999-2010. Mathematically, the publication efficiency index (PEIti) for the ith country in the tth year during the given period can be defined as follows:

$$PEI^t_i = \frac{(C^{t+2}_i / \sum C)}{(P^t_i / \sum P)}$$

C$t+2i$ is the citations by the ith country, y in the (t + 2)th year; ∑C is the citations by the ith country during the given citation period; Pti is the publications by the ith country in the tth year; ∑P is the publications by the ith country during the given publication period. It is obtained through dividing the percentage of citations "returns" by the percentage of publications "efforts". If PEI >1, this indicates that the impact of publications in a given field by a particular country is more than the research effort devoted to it during the period considered. Table 4 shows the PEI scores for the top-six countries.

Table 4: Publication Efficiency Index (PEI) of Top Countries in *Nipah virus* Research

Year	USA	Australia	Malaysia	France	Germany	UK
2008	1.18	1.15	2.14	4.35	0.91	1.62
2007	1.30	0.81	1.44	1.33	4.61	-
2006	1.12	1.59	1.62	0.47	2.52	3.44
2005	1.54	1.72	2.83	2.81	0.64	-
2004	0.81	1.44	0.70	0.59	0.34	0.29
2003	0.71	1.26	0.73	0.57	-	0.75
2002	0.82	0.84	0.64	0.70	-	-
2001	0.30	0.17	0.38	-	0.00	-
2000	0.63	0.75	0.62	-	-	0.29
1999	1.61	-	2.74	-	-	-
Mean	1.00	1.08	1.38	1.55	1.50	1.28

The results demonstrate that the impact of research publications in *Nipah virus* by the USA (PEI=1.0) is equal to the amount of effort devoted to it, while the remaining 5 countries: Australia, Malaysia, France, Germany, and UK demonstrated a PEI score greater than 1 (PEI>1). This means that for those five countries, the research performance is more than the research effort devoted to it during 1999 - 2010. USA and Malaysia were active in the *Nipah virus* research at the early stages (in year 1999 PEI>1 for USA and Malaysia). Australia displays good performance during 2003 to 2006. Additionally, Australia, France, Germany and UK did not produce publications in 1999, hence, they did not obtain any PEI value in that year (which is represented by dash). All six countries seem to display irregular fluctuant trends during year 2000 to 2002, which for all the country is below 1 (PEI<1, 2000 - 2002).

In summary the activity index (AI), attractive index (AAI) and publication efficiency index (PEI) are useful in comparing *Nipah virus* research performance by countries to the world's performance.

Performance by Institutions

Table 5 represents the list of the institutions, which have contributed at least 5 publications to *Nipah virus* during 1999–2010.

Table 5: Institutions with at least 5 Publications during 1999-2010

	Institution	Publications	Percentage (%)	Country
1	Commonwealth Scientific and Industrial Research Organization (CSIRO)	74	18.73	Australia
2	Center for Disease Control and Prevention	59	14.94	USA
3	University of Malaya	49	12.41	Malaysia
4	Uniformed Services University of the Health Sciences	28	7.09	USA
5	University of California, Los Angeles	19	4.81	USA
6	Universiti Putra Malaysia	13	3.29	Malaysia
7	Veterinary Research Institute	13	3.29	Malaysia
8	University of Kentucky	13	3.29	USA
9	University of Marburg	13	3.29	Germany
10	University of Queensland	10	2.53	Australia
11	Consortium for Conservation Medicine	10	2.53	USA
12	Emory University	9	2.28	USA
13	Cornell University	9	2.28	USA
14	Institute national de la sante et de la recherché medicale (INSERM)	9	2.28	France
15	Northwestern University	9	2.28	USA
16	Mount Sinai School of Medicine	9	2.28	USA
17	Ministry of Health	9	2.28	Singapore
18	Singapore General Hospital	8	2.03	Singapore
19	National Institute of Animal Health (NIAH)	8	2.03	Japan
20	Department of Primary Industries and Fisheries	7	1.77	Australia
21	Australian Animal Health Lab	7	1.77	Australia
22	University of Lyon	7	1.77	France
23	National Institute of Neurosciences	7	1.77	Singapore
24	University of Manitoba	7	1.77	Canada
25	National Institute of Allergy and Infectious Diseases	7	1.77	USA
26	Iowa State University	7	1.77	USA
27	Canadian Food Inspection Agency	6	1.52	Canada
28	Tan Tock Seng Hospital	6	1.52	Singapore
29	Queensland Department of Primary Industries	6	1.52	Australia
30	University of Pennsylvania	6	1.52	USA
31	Institute Pasteur	6	1.52	France
32	University of Georgia	6	1.52	USA
33	University of Tokyo	6	1.52	Japan
34	National Cancer Institute	6	1.52	USA
35	CUNY Mount Sinai School Of Medicine	5	1.27	USA
36	Department of Veterinary Services	5	1.27	Malaysia
37	University of Oxford	5	1.27	England
38	University of Texas	5	1.27	USA
39	International Centre for Diarrhoeal Disease Research	5	1.27	Bangladesh
40	Institute of Epidemiology Disease Control and Research	5	1.27	Bangladesh
41	University of California Davis	5	1.27	USA
42	Australian Bio Security Coop Research Centre for Emerging	5	1.27	Australia
43	World Health Organization	5	1.27	-

The total number of institutions that contributed to the publication in *Nipah virus* during the period studied is three hundred and ninety five (395) institutions. The five institutions which produced more than half of all publications (57.22%) individually or collaboratively during between 1999 and 2010 includes: Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia; Center for Disease Control and Prevention (CDC), USA; University of Malaya, (UM), Malaysia; Uniformed Services University of the Health Sciences, (USUHS), USA and University of California Los Angeles, (UCLA), USA . CSIRO was founded in 1926 and is one of the largest and most diverse scientific research institutions in the world (CSIRO 2012). The CDC is USA's premier health promotion, prevention, and preparedness agency and a global leader in public health(CDC 2012). The UM, USUHS and UCLA are top research universities in their respective countries.

Institutional Collaboration Network

We utilize the Bibexcel tool-box and Pajek network analysis software to visualize the degree of collaborations amongst institutions (Persson, Danell, and Schneider 2009; Kamada and Kawai 1989).To handle manageable data, we selected the top productive institutions and pair them with other institutions in the master list of institutions. The result of the network analysis is the map represented in Figure 2.
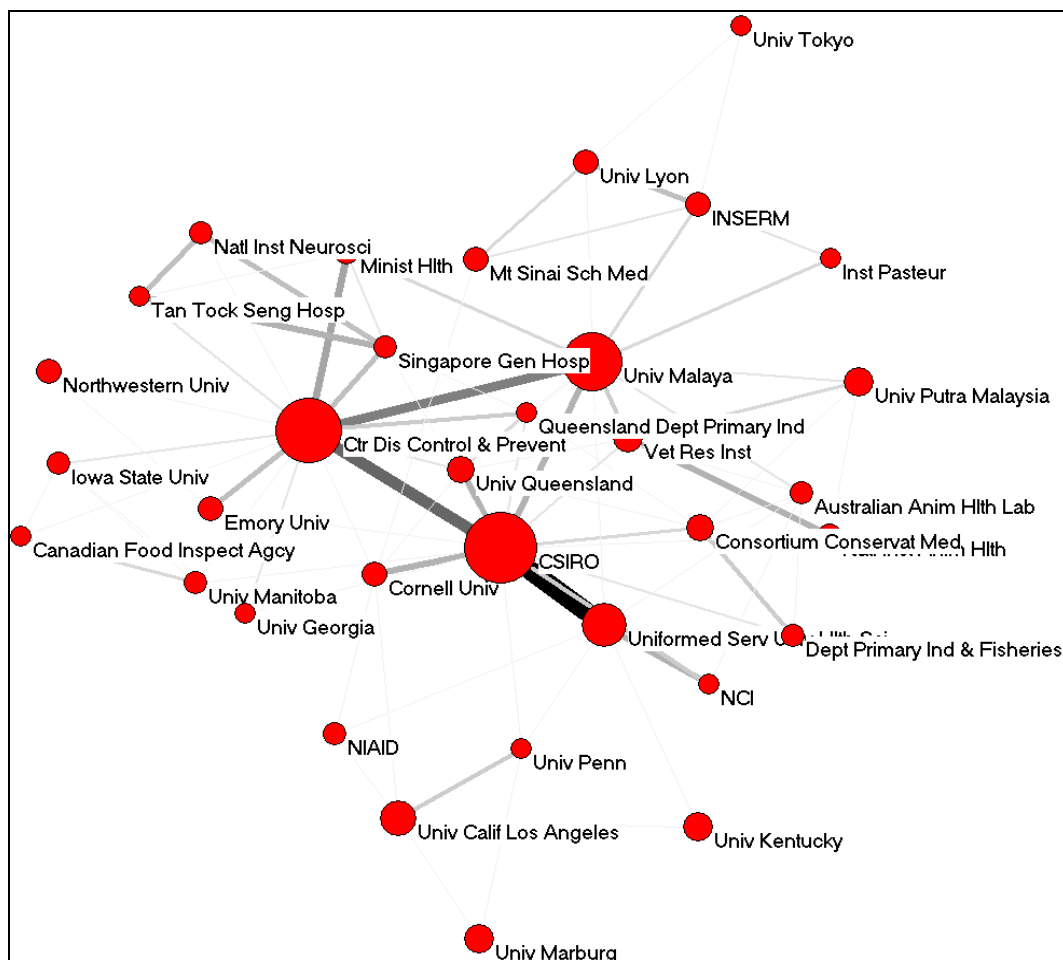

Figure 2: Institutional Collaboration Network Map in *Nipah virus* Publications (1999 – 2010)

The relative size of a node indicates institutional contribution to *Nipah virus* publications. The CSIRO is the largest institutional contributor followed by the CDC. Table 6 shows institutional contributions (the bigger the node in the map the larger the contribution) and institutional collaborations with at least five or more occurrences.

Table 6: Institutional Collaboration in *Nipah virus* Publications during 1999 – 2010

	Institutional collaborations			Collaboration frequency
1	CSIRO (Australia)	:::	Uniformed ServUnivHlthSci (USA)	18
2	CSIRO (Australia)	:::	Ctr Dis Control & Prevent (USA)	11
3	Ctr Dis Control & Prevent (USA)	:::	Univ Malaya (Malaysia)	9
4	Ctr Dis Control & Prevent (USA)	:::	MinistHlth (Singapore)	7
5	CSIRO (Australia)	:::	Univ Queensland (Australia)	6
6	National Cancer Inst (USA)	:::	Uniformed ServUnivHlthSci (USA)	6
7	Cornell Univ (USA)	:::	CSIRO (Australia)	6
8	CSIRO (Australia)	:::	Univ Malaya (Malaysia)	6
9	NatlInstAnimHlth (Japan)	:::	Vet Res Inst (Malaysia)	6
10	Singapore Gen Hosp (Singapore)	:::	Tan Tock SengHosp (Singapore)	6
11	Ctr Dis Control & Prevent (USA)	:::	Emory Univ (USA)	5
12	Ctr Dis Control & Prevent (USA)	:::	Singapore Gen Hosp (Singapore)	5
13	NatlInstNeurosci (Singapore)	:::	Tan Tock SengHosp (Singapore)	5
14	INSERM (France)	:::	Univ Lyon (France)	5
15	NatlInstNeurosci (Singapore)	:::	Singapore Gen Hosp (Singapore)	5

The collaboration map shows that CSIRO and USUHSfrequently collaborated (18 papers), followed by CSIRO, Australia and CDC, USA (11 papers). The CDC and UM, Malaysia also collaborated to produce 9 papers. The CSIRO and CDC have more international collaboration pair than any other institution during 1999-2010. Matthews et al. (2009) also observed that the growth in Australia's research publications is associated with international collaborations rather than purely domestic efforts and has resulted in sustained research growth and breakthroughs.

CONCLUSION

Through the use of the activity index AI, attractive index AAI and publication efficiency index PEI, we were able to compare performance of the top-six contributing countries active in *Nipah virus* research. The citation pattern in *Nipah Virus* is decreasing and plateauing and may be due to lower global interest as the cause of the disease has been ascertained and methods of controlling it is known. However, countries affected by this disease are still active in finding out new strains of the disease, as outbreaks still occur, although considerably reduced. Analysis of data from WoS shows that more counties are participating in *Nipah virus* research in recent years, and the top contributors are the USA, Australia, Malaysia, France, Germany and England. However, using other indices such as the AI, AAI and PEI, revealed that although, the USA has the highest number of publications, Australia is the most productive country based on per capita followed by Malaysia. Malaysia has the highest AI score, which means that Malaysian contribution to this research is more than the world's average between 1999 and 2010.The relative citation impact in *Nipah virus* research by USA, Australia, Malaysia, France and England

surpass the world average during the period studied. However, Germany seems also to be improving in recent years (during 2009 and 2010) in terms of research contribution and citation impact. Hu and Rousseau (2009) pointed that most Asian countries are pacing up in the science race by stepping up and preferring to solve local scientific problems they are actually solving the world problem as exemplified by the *Nipah virus,* which first hit Malaysia and later reported in other Asia Pacific countries. Furthermore, we found that, more than half of the publications were produced either individually or collaboratively by five institutions, CSIRO in Australia, CDC in USA, University of Malaya, Malaysia, Uniformed Services University of the Health Sciences, USA and UCLA, USA. CSIRO, Australia and CDC, USA have more international collaboration highlighting that Australia and USA are the friendliest partner in *Nipah virus* research. As such, to be active, relevant and sustainable, collaboration is of great importance. This study may be limited because it covers a small field in virology. However, it is nonetheless a field that is still very relevant to tropical countries, especially those along the migratory path of the bats.

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