Scientific impact of multiple sclerosis and neuromyelitis optica spectrum disorder research from Southeast Asia: A bibliometric analysis

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ABSTRACT

Background: Scientific productivity in the Southeast Asian (SEA) region in the field of multiple sclerosis and neuromyelitis optica spectrum disorder (MS/ NMOSD) was hypothesized to be low in magnitude. The aim of this study was to determine and compare MS/ NMOSD research outputs among the SEA countries in terms of established bibliometric indices. The association between these productivity indices and relevant country-specific socioeconomic factors was also determined.

Methods: A systematic review was conducted to include all relevant published MS/ NMOSD studies in the SEA indexed in MEDLINE, Embase, Scopus and CENTRAL from the inception of these databases to August 1, 2019. Quantity of research productivity was measured in terms of the total published documents. Quality of research impact was evaluated by assessing the study designs of the published reports, publications in journals with impact factor (IF) and PlumX Metrics (citations, usage, captures, mentions and social medias). Population size, gross domestic product (GDP) per capita, percentage (%) of GDP allocated to research and development (R&D), and the total number of neurologists reported in each country were obtained from reliable published data.

Results: Out of 3,547 articles identified, only 142 articles fulfilled the eligibility criteria; therefore, the total number of publications in the SEA region related to MS/ NMOSD was deemed low in quantity. Most studies were cross-sectional and case reports/ series; hence, most studies offered low level of evidence. Since the aggregate scores in citations, usage, captures, mentions, and social medias in PlumX Metrics and publications in journals with IF were low, the overall quality of the published articles was considered low. Thailand (57 articles), Malaysia (40) and Singapore (29) contributed to the majority of publications on the topic-. GDP per capita was statistically correlated with usage. Percent GDP for R&D was positively correlated with total publications, usage, captures and social mediaindices.

Conclusion: In conclusion, the scientific impact of MS/ NMOSD in the SEA was considered low in quantity and quality. This study must encourage researchers in the SEA to produce greater volumes of high-quality publications in this particular field and motivate governments to increase % GDP for R&D for the benefit of patients suffering fromthese rare and disabling conditions.

1. Introduction

Multiple sclerosis (MS) and neuromyelitis optica spectrum disorders (NMOSD) are autoimmune, inflammatory and demyelinating conditions that mainly affect the central nervous system (CNS). The major clinical feature of MS is the dissemination of CNS dysfunction in space and time (Thompson et al., 2018). The reported prevalence and incidence rates of MS approximately ranges range from 10–200/ 100,000 persons and 2–18/ 100,000 person-years, respectively (Koch-Henriksen and Sørensen, 2010). On the other hand, NMOSD is a

disorder distinct from MS that typically involves the optic nerves and spinal cord, and is associated with serum aquaporin-4-immunoglobulin G antibodies (Wingerchuk et al., 2015). NMOSD occurs less frequently than MS with documented range of prevalence and incidence rates of 0.51–4.4/ 100,000 persons and 0.053–0.4/ 100,000 person-years, respectively (Etemadifar et al., 2015).

In particular, information on disease frequency of MS/ NMOSD in most of the Southeast Asia (SEA) nations is considerably lacking (Eskandarieh et al., 2016; Espiritu et al., 2019; Hor et al., 2018; Viswanathan et al., 2018). It is theorized that the scarcity of important data and low research productivity in this region are caused not only by understandably low prevalence or incidence in this region, but also by various relevant socioeconomic factors. At present, the total population in the SEA is 662 million, which is 8.56% of the world's population, while the current reported number of neurologists in this region was estimated to be at 3354 (Thuy Le et al., 2019; Worldometers, 2019a, 2019b). The SEA region is projected to attain an average gross domestic product (GDP) growth of 5.2% between 2018 and 2022, with notably increasing allocation for Research and Development (R&D) share from the total GDP (OECD, 2018). Although there was no significant association between GDP per capita and research outcomes according to a study of 40 Asian countries, other relevant factors like R&D spending, number of universities and number of indexed journals were shown to be positively correlated with the number of publications, citations, and *h*-index in several science and social science subjects (Meo et al., 2013). It is unknown, however, if similar associations exist with other socioeconomic indicators with regards to MS/ NMOSD research especially in the SEA region, where research productivity is hypothesized to be low.

Research productivity and impact of a particular author or journal are traditionally measured by certain bibliometrics, such as the gross number of published documents and publications in journals with impact factor (IF) (Thonon et al., 2015). For wider evaluation of impact of research articles, alternative metrics, dubbed as "*altmetrics*", such as the PlumX Metrics, are increasingly being integrated in biomedical research databases (Lindsay, 2016). PlumX Metrics evaluates the following 5 broad key domains of scientific impact: citations, usage, captures, mentions and social medias (Lindsay, 2016).

Currently, there is a gap in knowledge with regards to the status of MS/ NMOSD scientific outputs in the SEA. The link between research productivity and various country-specific socioeconomic factors is also unclear. Therefore, the aim of this study was to assess and compare MS/ NMOSD research productivity among SEA countries in terms of bibliometric indices, such as total publications, publications in journals with IF and PlumX Metrics. The top journals in which most of the articles were published and the top SEA institutions with the highest total publications were also determined. The association between the bibliometric parameters and relevant socioeconomic factors such as the population size, GDP per capita, % GDP allocated to R&D and number of neurologists per country in this region was also explored in this study.

2. Methods

A systematic review was conducted to retrieve all relevant articles in MS/ NMOSD research in SEA countries. The Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) consensus statements were followed in this review (Liberati et al., 2009).

2.1. Criteria for considering studies for this review

We included studies that employed any study design (systematic reviews with or without meta-analyses, randomized controlled trials, prospective/ retrospective cohort, case-control studies, cross sectional study, case reports/ series, animal/ laboratory studies and expert reviews). Indexed documents in the form of letters to the editor, commentaries, proceedings, books and conference papers were excluded.

We considered studies that involved either human, animal or in-vitro models of MS or NMOSD in this review. Studies that involved subjects with other causes of central demyelination syndromes were excluded. We included studies with at least one author affiliated with at least one institution from any of the 11 SEA nations, namely: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste and Vietnam.

2.2. Search methods for study identification, study selection and data extraction

The following major healthcare electronic databases were systematically searched for relevant articles: MEDLINE by Pubmed, Embase, Scopus, and CENTRAL by the Cochrane Library. We searched the relevant records of indexed articles from the inception of these electronic databases until August 1, 2019. We employed the following relevant search strategies in the databases: [(multiple sclerosis) OR (neuromyelitis optica OR neuromyelitis optica spectrum disorders OR Devic disease)] AND (Brunei OR Cambodia OR Indonesia OR Laos OR Malaysia OR Myanmar OR Philippines OR Singapore OR Thailand OR Timor-Leste OR Vietnam). Titles and abstracts of records generated from the systematic search were evaluated using predetermined screening criteria. Full-text articles were obtained for records satisfying the screening criteria and these articles were subjected to predetermined eligibility criteria. Records that fulfilled the eligibility criteria were included in this review.

We obtained the following data from each of the included studies: country and affiliated institutions of the author, year of publication, study design, subject discussed (e.g. therapy, prognosis, diagnosis, prevalence/ incidence, animal studies, in-vitro or laboratory studies), disease studied (MS, NMOSD or both) and the journal name in which the article was published.

2.3. Sources of bibliometric indices and country-specific socioeconomic data

Information about the 2-year IF (2018) of the journals, where the included articles were published, were acquired from the latest Journal Citation Reports (JCR), a product of the Clarivate Analytics (Clarivate Analytics, 2019). PlumX Metrics, a product of Plum Analytics, is a multi-bibliometric statistic that was designed to determine the research impact of published articles using the following 5 broad categories: (1) *Citations*, which reflect the number of both traditional and societal citations; (2) *Usage*, which denotes the number of clicks, views, downloads, library holdings and video plays; (3) *Captures*, which signify the number an article was bookmarked, favorited, exported and saved in reference managers; (4) *Mentions*, which represent the number of citations in blog posts, news, comments, reviews and forum topics; and (5) *Social Medias*, which denote the number of tweets, likes and shares in social media platforms (Lindsay, 2016). PlumX statistics for each included study were retrieved using the plu.mx website (Plum Analytics, n.d.). Quality assessment was performed by evaluating the number of the included studies that were published in journals with IF, by assessing the scores in the PlumX metric components and by determining the study designs of the included studies.

The population size of each country was obtained from the *Worldometers* website (Worldometers, 2019a). Information on GDP per capita (purchasing power parity, international dollar unit) was retrieved from the International Monetary Fund (IMF) website ("World Economic Outlook Database," n.d.). Data on percent (%) allocation of GDP for R&D were obtained from the *World Bank* website ("World Bank," n.d.). The total number of neurologists in each country was obtained from published data (Roxas et al., 2017; Thuy Le et al., 2019). Further attempts to update the number of reported neurologists in each country were performed by searching the official websites, by sending e-mails and by phone-calling each neurological society in the SEA. The number of population per neurologist for each country was

computed by dividing the total population by the number of neurologists.

2.4. Data synthesis

Statistical analyses were performed using the IBM® SPSS® Statistics for Macintosh, Version 23 (Armonk, NY: IBM Corp.). Descriptive statistics were employed for categorical variables using frequencies and proportions. Correlations between country-specific characteristics and bibliometric indices were determined using Pearson correlation coefficient (r), with statistical significance detected if p-value is less than 0.05.

3. Results

3.1. Results of the systematic search

A total of 3,547 articles (MEDLINE: 523; Embase: 263 Scopus: 2,685; CENTRAL: 76) were obtained using the search strategy. Five hundred two records were duplicates and were immediately discarded. Out of 3,045 records that were screened, 2,900 records were excluded. After eligibility assessment, 142 articles were included in the analysis. The PRISMA diagram for this review is illustrated in Fig. 1.

3.2. Characteristics of the included studies

Study designs of included articles were cross-sectional (53/142 articles; 37.3%), case report/ series (36/142; 25.4%), cohort (27/142; 19.0%), systematic review/ meta-analyses (13/142; 9.2%), expert reviews (6/142; 4.2%), pre-post study designs (3/142; 2.1%), case-control (2/142; 1.4%), randomized controlled trial (1/142; 0.7%), and economic (1/142; 0.7%) studies. There was no animal or in-vitro studies identified in the systematic search. Most studies were related to the description of the clinical profile (62/142 articles, 43.7%), diagnosis

Table 1
Top journals publishing MS/NMOSD articles from SEA ($N = 142$).

Journal Name	Impact Factor	Total publications, n (%)
Multiple Sclerosis and Related Disorders	2.725	17 (12.0)
Journal of the Medical Association of Thailand	NA	13 (9.2)
Multiple Sclerosis Journal	5.649	9 (6.3)
Neurology Asia	0.218	8 (5.6)
Journal of Neuroimmunology	2.832	5 (3.5)
Annals of the Academy of Medicine Singapore	0.819	5 (3.5)
Neurology	8.869	4 (2.8)
Multiple Sclerosis International	NA	4 (2.8)
Molecular Neurobiology	4.586	3 (2.1)
PLoS ONE	2.776	3 (2.1)
Journal of the Neurological Science	2.651	3 (2.1)
Medical Journal of Malaysia	NA	3 (2.1)
Neuroradiology	2.504	2 (1.4)
Journal of Clinical Neuroscience	1.593	2 (1.4)
International Journal of Ophthalmology	1.189	2 (1.4)
Archives of Neurology	NA	2 (1.4)
Clinical and Experimental Neuroimmunology	NA	2 (1.4)

NA, Not available.

(23/142; 16.2%) and therapy (22/142; 15.5%) of MS/ NMOSD. There were 94 (66.2%), 41 (28.9%), and 7 (4.9%) articles related to MS, NMOSD, and both MS/ NMOSD, respectively.

3.3. Top journals that published SEA papers on MS/ NMOSD

Several SEA documents on MS/ NMOSD were published in *Multiple Sclerosis and Related Disorders* (17/142 articles; 12.0%), *Journal of the Medical Association of Thailand* (13/142; 9.2%) and *Multiple Sclerosis Journal* (9/142; 6.3%) (see Table 1).
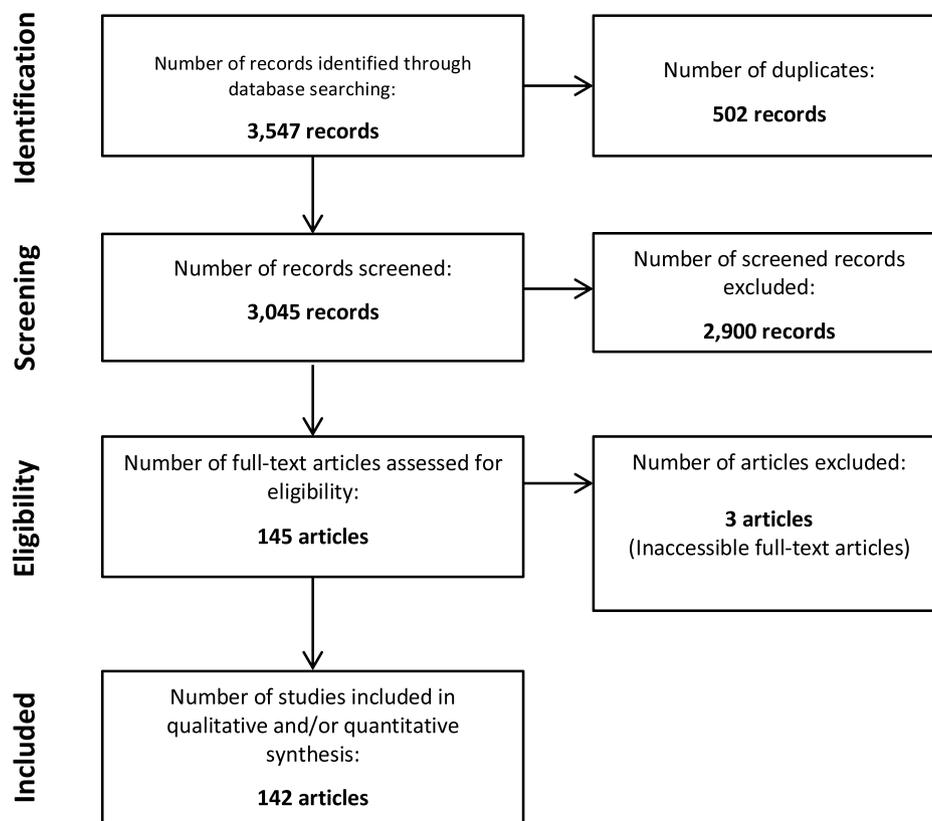

Fig. 1. PRISMA flow diagram of information.

Table 2

Top SEA institutions that published MS/ NMOSD articles.

Institution Name	Base Country	Total publications
Siriraj Hospital-Mahidol University	Thailand	25
National Neuroscience Institute-Tan Tock Seng Hospital	Singapore	15
Kuala Lumpur Hospital	Malaysia	9
University of Malaya	Malaysia	9
Bumrungrad International Hospital	Thailand	9
Prasat Neurological Institute	Thailand	9
Ramathibodi Hospital-Mahidol University	Thailand	8
Singapore General Hospital	Singapore	7
Chulalongkorn University	Thailand	7
Monash University Malaysia	Malaysia	7
National University of Singapore	Singapore	6
King Chulalongkorn Memorial Hospital	Thailand	6
University Sains Malaysia	Malaysia	5
Institute for Medical Research	Malaysia	4
Philippine General Hospital-University of the Philippines Manila	Philippines	4
Khon Kaen University	Thailand	4
Universitas Indonesia	Indonesia	3
DR. Cipto Mangunkusumo General Hospital	Indonesia	3
University of Putra Malaysia	Malaysia	3
Naresuan University	Thailand	3

3.4. Top SEA institutions with the highest number of publications on MS/ NMOSD

Most articles on MS/ NMOSD published by the authors from SEA are associated with the following institutions: Siriraj Hospital-Mahidol University, Thailand (25 articles); National Neuroscience Institute-Tan Tock Seng Hospital, Singapore (15); Kuala Lumpur Hospital, Malaysia (9); University of Malaya, Malaysia (9); Bumrungrad International Hospital, Thailand (9); and Prasat Neurological Institute, Thailand (9) (see Table 2).

3.5. Bibliometric indices measured

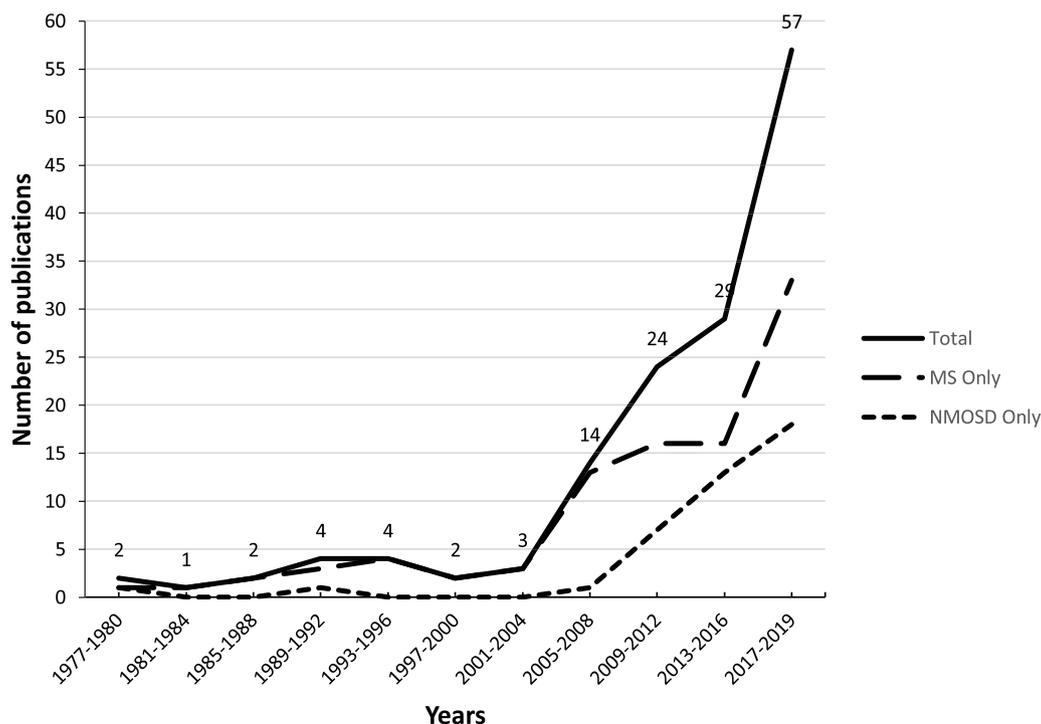The increasing number of publications in the field of MS/ NMOSD in

SEA countries from 1977 to 2019 is shown in Fig. 2. The comparative graph of publications among the SEA countries is displayed in Fig. 3. The total publications related to MS/ NMOSD per country is listed in Table 3.

Overall, the top 3 countries with the greatest number of publications were Thailand (57/142 articles; 40.1%), Malaysia (40/142; 28.2%) and Singapore (29/142; 20.4%). In particular, the following 3 countries had the highest number of publications on MS: Thailand (34/94 articles; 36.2%), Malaysia (26/94; 27.6%) and Singapore (25/94; 26.6%). For NMOSD, the top 3 countries with the greatest number of publications were the following: Thailand (19/41 articles; 46.3%); Malaysia (12/41; 29.3%) and Singapore (4/41; 9.8%). For publications discussing both MS and NMOSD, Thailand, Malaysia and Indonesia had four articles, two articles, and 1 article, respectively.

Thailand (38/142 articles; 26.8%), Malaysia (27/142; 19.0%), and Singapore (14/142; 9.9%) had the highest number of papers published in journals with IF. In terms of PlumX Metrics, the top 3 countries (in descending order) that had the highest scores in each of the domains were the following: citations (Thailand, Singapore, and Malaysia), usage (Singapore, Malaysia, and Thailand), captures (Thailand, Singapore, and Malaysia), mentions (Thailand, Singapore, and Malaysia), and social medias (Malaysia, Thailand, and Singapore). The pooled results of PlumX categories for each SEA country is shown in Table 3.

3.6. Country-specific socioeconomic factors and correlation with bibliometric indices

The total population size (in millions) in the region was 662.38 [per country range, 0.44 (Brunei) to 269.54 (Indonesia)] (Worldometers, 2019a). The GDP per capita for the entire SEA region was 12,888.4 (units in purchasing power parity, international dollars) [per country range, 4334.8 (Cambodia) to 100,344.7 (Singapore)] ("World Economic Outlook Database," n.d.). The median percentage GDP for R&D was 0.16 [per country range, 0.04 (Brunei and Laos) to 2.16 (Singapore)] ("World Bank," n.d.). The total number of neurologists reported in the region was 3354 (per country range, 0 (Timor-
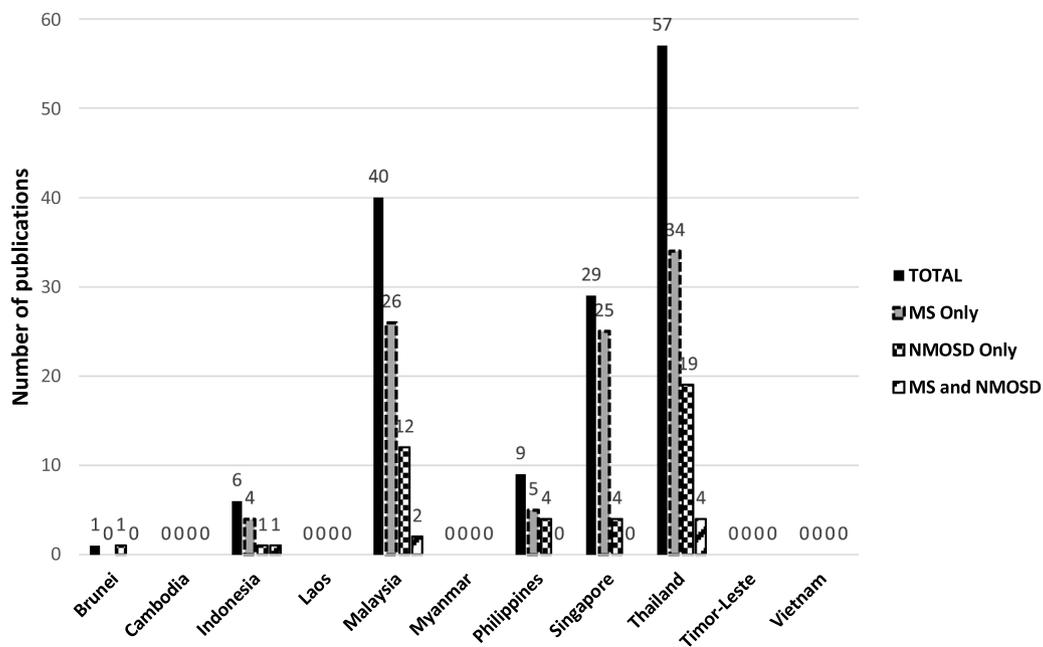

Fig. 2. Trend of MS/NMOSD publications through the years.

Fig. 3. Distribution of MS/NMOSD research publications per SEA country.

Table 3
Country-specific characteristics and summary of relevant bibliometrics for MS and NMOSD in the SEA countries.

Country	Population in millions	GDP per Capita*	% GDP for R&D	Total neurologists	Number of population per neurologist	Total publications	Citation[†]	Usage[†]	Captures[†]	Mentions[†]	Social Medias[†]
Brunei	0.44	79,529.9	0.04	2	219,668.0	1	0	0	0	0	0
Cambodia	16.48	4334.8	0.12	5	3,296,529.2	0	0	0	0	0	0
Indonesia	269.54	13,229.5	0.08	1,150	234,379.5	6	18	2597	251	0	10
Laos	7.06	7,924.6	0.04	3	2,354,747.3	0	0	0	0	0	0
Malaysia	32.45	30,859.9	1.3	120	270,453.8	40	185	9,527	398	1	205
Myanmar	54.34	6,216.7	0.16	23	2,362,440.8	0	0	0	0	0	0
Philippines	108.11	8,935.9	0.14	506	254,367.8	9	170	227	126	0	1
Singapore	5.87	100,344.7	2.16	100	58,681.0	29	350	11,653	1,140	6	64
Thailand	69.31	19,476.5	0.78	645	107,451.4	57	655	3,893	1,761	47	137
Timor-Leste	1.35	5,241.8	NR	0	–	0	0	0	0	0	0
Vietnam	97.43	7,510.5	0.44	800	121,786.3	0	0	0	0	0	0
Total	662.38	(12,888.4[‡])	(0.16[§])	3,354	(197,488.2[¶])	142	1,378	27,897	3,676	54	417

GDP, Gross domestic product; NR, Not reported; R&D, Research and Development;.

* The unit used for GDP per capita (2018) was purchasing power parity, international dollars.
[†] Citations, usage, captures, mentions, and social medias are components of the PlumX Metrics.
[‡] SEA GDP per capita computed by dividing the total SEA GDP by the total SEA population.
[§] Median % GDP for R&D.
[¶] Number of population per neurologist in the entire SEA region computed by dividing the total SEA population by the total SEA neurologists.

Leste) to 1150 (Indonesia) (Roxas et al., 2017; Thuy Le et al., 2019). The number of population per neurologist in the region was 197,488.2 [per country range, 58,681.0 (Singapore) to 3296,529.2 (Cambodia)]. The socioeconomic characteristics of each country in the SEA are summarized in Table 3.

GDP per capita significantly correlated with only "usage" ($p = 0.044$). Percent GDP for R&D had significant statistical correlation with "total publications" ($p = 0.037$), "usage" ($p = 0.000$), "captures" ($p = 0.045$), and "social medias" ($p = 0.048$). The rest of the correlational analyses were non-significant. The results of the correlational analyses between country-specific variables and research productivity indicators are provided in Table 4.

4. Discussion

To our knowledge, this study has brought forth the only review of the scientific impact of MS/ NMOSD research articles from the SEA,

with addition of correlational analyses between country-specific socioeconomic characteristics and bibliometric indices.

Research productivity among SEA countries appeared to be very low in quantity with only 142 MS/ NMOSD articles published since the beginning of indexing of major healthcare databases that were systematically searched in this review. From the 1970s to early 2000s, the SEA region had contributed very few published reports. Notably, there seemed to be only a recent rise of publications from the region in the last 5 years. On the other hand, the collective assessment of quality of these articles in terms of the PlumX citations, usage, captures, mentions, social medias and publications in high-impact journals was substantially muted. In addition, the total number of publications in journals with IF was- low. Most published studies were cross-sectional and case report/ series, which provide low level of evidence. Among the SEA countries, Thailand, Malaysia and Singapore consistently scored high in all of the research productivity indices compared to other SEA countries. Moreover, these countries, represented by their reputable

Table 4
Correlational analysis between country-specific and bibliometric indices.

Country-specific characteristics	Bibliometric indices	R-value	P-value
Population	Total publications	−0.034	0.921
	Citations	−0.038	0.912
	Usage	−0.092	0.788
	Captures	0.003	0.992
	Mentions	0.007	0.985
	Social Medias	−0.104	0.761
GDP per capita	Total publications	0.279	0.406
	Citations	0.286	0.394
	Usage	0.616	0.044*
	Captures	0.367	0.267
	Mentions	0.034	0.922
	Social Medias	0.208	0.540
% GDP for R&D	Total publications	0.663	0.037*
	Citations	0.587	0.075
	Usage	0.948	0.000**
	Captures	0.642	0.045*
	Mentions	0.241	0.502
	Social Medias	0.636	0.048*
Total neurologists	Total publications	0.157	0.646
	Citations	0.195	0.565
	Usage	−0.034	0.920
	Captures	0.224	0.508
	Mentions	0.256	0.448
	Social Medias	0.015	0.965
Number of population per neurologist	Total publications	−0.478	0.162
	Citations	−0.452	0.189
	Usage	−0.443	0.199
	Captures	−0.439	0.204
	Mentions	−0.270	0.450
	Social Medias	−0.382	0.276

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

affiliated institutions, had produced a higher number of publications in journals with relatively high IF. In contrast, Philippines, Indonesia and Brunei had a fewer number of publications, while Cambodia, Laos, Myanmar, Timor-Leste and Vietnam had no relevant indexed publications on MS/ NMOSD in the explored databases.

A recent study on epilepsy-related research outputs in SEA emphasized that economy type could play the most significant role in the volume of scientific productivity of a country (Thuy Le et al., 2019). Knowledge-based economy states, such as Malaysia, Thailand and Singapore, place a major weight on the attainment of knowledge and skills, establishment of educational institutions, research development and technology advancement; hence, the amount and impact of publications from these countries were considerably greater (Litsareva, 2017; Thuy Le et al., 2019). On the other hand, countries with non-knowledge-based economy, in which the rest of the SEA nations were classified, heavily emphasized on traditional agriculture and natural resources extraction that employed low-skilled workers; hence, there was relatively lower yield of research productivity in these countries at least on epilepsy (Thuy Le et al., 2019) and on MS/ NMOSD as seen in this current study.

Among the socioeconomic factors studied in this review, % GDP for R&D was significantly associated with several bibliometric indices. In particular, it was positively correlated with "total publications," a finding that was consistent with another report that involved publications in high-ranking radiology journals (Halpenny et al., 2010). Positive correlations between % GDP for R&D and certain other PlumX metric indices (usage, captures, and social medias) were also found in this study.

Population size appeared to have no direct link to all the bibliometric indicators measured in this study, which is consistent with other report on the impact of general clinical neurology research involving top 50 countries in the world based on their total published documents (Jamjoom and Jamjoom, 2016). Conversely, these observations

conflicted with other disciplines such as rheumatology, podiatry, and arthroscopy (Cheng and Zhang, 2013; Liang et al., 2015; Luo et al., 2015).

The increased burden of providing healthcare services by the clinicians is also hypothesized to cause a substantial negative influence on achieving research productivity. High population-to-neurologist ratio may compel a practitioner to allocate insufficient time to accomplish essential research outputs. In this study, however, the number of population per neurologist per country did not correlate well with any of the bibliometric indices. Further studies are necessary to determine the effect of burden of service delivery or high population per neurologist to scientific productivity,

There is an apparent sizable disparity in terms of GDP per capita among the countries in SEA. Seven out of 11 countries (Cambodia, Indonesia, Laos, Myanmar, Philippines, Timor-Leste and Vietnam) can be classified under the lower-middle income countries; two as high-middle income countries (Malaysia and Thailand); and two as high-income countries (Brunei and Singapore). Between the two countries with the highest GDP per capita, Singapore contributed approximately 20% of the total publications from the SEA in the MS/ NMOSD field while Brunei had only 1 published record. This is quite logical since Singapore provided higher allocation of % GDP for R&D compared to Brunei and to other SEA countries.

The GDP per capita correlated significantly with only one bibliometric index (usage) in this study. Published articles reported conflicting results in terms of association between GDP per capita and research productivity indices, wherein some documents (Cheng and Zhang, 2013; Liang et al., 2015; Luo et al., 2015) showed significant correlation, while other records (Meo et al., 2013; Meo and Usmani, 2014) showed no association.

As far as we know, this is the first study which dealt with measuring research productivity in the field of MS/ NMOSD. There is no available data yet in other regions of Asia as well as in other regions in other continents in this subject matter. The strength of this current review could be attributed to its comprehensive exploration of the databases surveyed from the earliest indexed record up to the present publications. Moreover, the accuracy of the inclusion of published documents was ensured since a systematic manner of searching, screening, and determining eligibility of relevant studies was performed. However, this review only included studies that were indexed in MEDLINE, Embase, Scopus, and CENTRAL; and therefore, this study could have not captured the scientific impact of articles not listed in these major healthcare databases. In addition, due to their individual inherent limitations, the bibliometric indicators employed in this study were not considered flawless and should be interpreted contextually since these measurements might not utterly demonstrate the impact and influence of these published documents to the scientific community, policymakers and to the society (Bornmann, 2014; Ortega, 2018; Roldan-Valadez et al., 2019). At present, there is no universally accepted single marker of scientific productivity to evaluate with complete certainty the quantity and quality of publications. Finally, another limitation of this study is that other significant correlational analyses such as the number of magnetic resonance imaging (MRI) machine, an essential tool for the diagnosis of MS/ NMOSD, available in each country in the SEA region to various research productivity indices were not performed due to the absence of relevant data.

Based on the current status of scientific productivity in the SEA region, research endeavors for MS/ NMOSD should be further encouraged. The low scientific output in this region should not be considered as an impediment, but rather, should be seen as a new opportunity for research especially for local scientists, clinicians and policymakers. To advance the capacity of this region to produce greater magnitudes of scientific publications, global partnerships with established centers of MS or NMOSD could be of advantage. Significant apportionment of resources to escalate the number of manpower (neurologists in particular) may improve research activities in the SEA

countries. Lastly, increasing the allocation of GDP to R&D and perhaps intensifying the local and international funding of research activities related to MS/ NMOSD with the help of their respective local government and non-government organizations could significantly improve the standing of scientific outputs in this region.

5. Conclusions

In conclusion, the overall scientific productivity and impact of MS/ NMOSD publications in the SEA were considered low in magnitude. Malaysia, Thailand and Singapore dominated the production of high quantity and quality research papers in the region possibly due to its economy type. Percent GDP allocated to research and development may be directly related to research outputs on MS/ NMOSD. The current status of research productivity in the SEA, as reflected in the pooled bibliometric analyses in this review, should encourage researchers, healthcare providers and policymakers to produce greater volumes of high-quality publications in the field of MS and NMOSD for the benefit of local patients with these rare conditions.

Ethical statement

The 1964 Declaration of Helsinki and its later amendments on ethical standards were followed in the performance and writing of this study.

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CRediT authorship contribution statement

Adrian I. Espiritu: Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Carl Froilan D. Leochico:** Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Karl Josef Niño J. Separa:** Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Roland Dominic G. Jamora:** Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors have nothing to disclose.

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