BİBLİYOMETRİK ÇALIŞMA/ BIBLIOMETRIC STUDY

A Bibliometric and Trend Analysis on Primary Amebic Meningoencephalitis

Primer Amebik Meningoensefalit Üzerine Bir Bibliometrik ve Trend Analizi

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ABSTRACT
Background: In this study, bibliometric methods were used to investigate research trends on Primary Amebic Meningoencephalitis (PAM).
Methods: Data from 1970 to 2021 were acquired from the Web of Science database.
The inclusion condition was developed as follows: "Primary Amebic Meningoencephalitis," TS (Topic). The research trend was explored by examining the distribution of nations, journals, authors, funding organizations, author keywords, affiliations, authorship patterns, and co-authorship relationships.
Results: Out of a total of 339 documents retrieved, 244 (71.976%) were journal articles. The highest number of publications (7.377%) were made in 2021. Over the past 20 years, there has been a gradual increase in the number of publications in PAM research and 47.54 (%) of the articles were published since 2010. The articles were from 34 different research fields, mainly in Microbiology (27.869%), Parasitology (20.902%), and Infectious Diseases (13.115%). Articles on PAM have been published from 39 countries on 5 continents. The number of articles is only a few hundred, mainly from the United States, Australia, Europe, and some Asian countries over the past fifty years. The only country with more than 100 (n=117) articles in PAM research was the United States of America (USA). The articles that were published in the USA had 5240 total citations (21.48 per article), and their average H index was 37.
Conclusion: The number of published articles on PAM is limited in countries other than the USA. Increasing the number of articles published on PAM by countries other than the USA would contribute to the literature.
Keywords: Primary amebic meningoencephalitis; bibliometric analysis; naegleria fowleri; web of science

ÖZET
Giriş: Bu çalışma, Primer Amibik Meningoensefalit (PAM) konusundaki araştırma eğilimlerini bibliyometrik yöntemler kullanarak değerlendirmeyi amaçlamaktadır.
Yöntem: 1970-2021 yılları arasındaki veriler Web of Science veri tabanından elde edilmiştir. Dahil etme koşulu aşağıdaki gibi geliştirilmiştir: "Primary Amebic Meningoencephalitis," Başlık (Konu). Araştırma eğilimi, ulusların, dergilerin, yazarların, fon sağlayan kuruluşların, yazar anahtar kelimelerinin, bağlantıların, yazarlık modellerinin ve ortak yazarlık ilişkilerinin dağılımı incelenerek araştırıldı.
Bulgular: Ulaşılan toplam 339 dokümanın 244'ü (%71,976) dergi makalesi idi. En fazla yayın (%7,377) 2021 yılında yapılmıştır. Son 20 yılda, PAM araştırmalarındaki yayın sayısında kademeli bir artış olmuştur ve makalelerin 47,54'ü (%) 2010 yılından bu yana yayınlanmıştır. Makaleler, başta Mikrobiyoloji (%27.869), Parazitoloji (%20.902) ve Enfeksiyon Hastalıkları (%13.115) olmak üzere 34 farklı araştırma alanından gelmektedir. PAM ile ilgili makaleler 5 kıtadaki 39 ülkeden yayınlanmıştır. Makale sayısı, son elli yılda ağırlıklı olarak Amerika Birleşik Devletleri, Avustralya, Avrupa ve bazı Asya ülkelerinden olmak üzere yalnızca birkaç yüzdür. PAM araştırmalarında 100'den fazla (n=117) makaleye sahip tek ülke Amerika Birleşik Devletleri'dir (ABD). ABD'de yayımlanan makalelerin toplam atıf sayısı 5240 (makale başına 21,48) ve ortalama H indeksi 37'dir.
Sonuç: ABD dışındaki ülkelerde PAM ile ilgili yayınlanmış makale sayısı sınırlıdır. ABD dışındaki ülkeler tarafından PAM konusunda yayınlanan makale sayısının artırılması literatüre katkı sağlayacaktır.
Anahtar kelimeler: Primer amibik meningoensefalit, bibliometrik analiz, naegleria fowleri; web of science

Introduction

Primary amebic meningoencephalitis (PAM) is an uncommon but mostly fatal brain infection (severe hemorrhagic meningoencephalitis) caused by the free-living amoeba *Naegleria fowleri*, which is found in warm fresh water and soil[1,2]. Clinical and laboratory features of PAM resemble those of acute bacterial meningitis, and PAM has a fulminant course[1]. Warm waterways, such as freshwater lakes, warm drinking water sources, and hot springs, are environments adapted by *N. fowleri*. Soil and water in temperatures between 86°F and 113°F (between 30°C and approximately 45°C) are the most propitious to proliferate for *N. fowleri*. However, the amoeba is not found in saltwater systems[2-4].

The first case of PAM was reported in 1962 in Florida, USA. Malcolm Fowler and R. F. Carter, who discovered and described the disease primary amoebic meningoencephalitis (PAM) in Australia in 1965, gave amoeba the name *N. fowleri*. It has been reported in more than 16 countries since 1965[5].

PAM occurs when otherwise healthy individuals come into contact with heated, untreated, or inadequately cleaned water. *N. fowleri*-contaminated water enters the nose and enables the amoebae to travel through the cribriform plate and the olfactory nerve to the brain, where *N. fowleri* causes damage[6]. The incubation period of PAM is between 2 to 15 days. It may be misdiagnosed as meningitis; due to similar symptoms such as altered mental state, vomiting, seizures, anorexia, and coma. 3–7 days after the onset of symptoms is the expected time frame for death. In the autopsy series, acute hemorrhagic necrosis was found in the cerebral cortex and olfactory bulb[6,7]. Since 1962, the United States of America (USA) Centers for Disease Control and Prevention (CDC) have kept a database of PAM cases that were reported in the USA. The database includes details on dates, locations, and possible exposures[5].

Although the global incidence is unknown, PAM is believed to be overlooked and underreported. *N. fowleri* may infect anyone, albeit PAM is more frequently seen in young boys, especially children[8]. Despite advances in supportive therapy and antimicrobial chemotherapy, the mortality rate associated with PAM is still over 95%[9].

Bibliometrics analyzes academic literature's bibliographic data to determine the organization, productivity, and research trends. Bibliometric analyses trace the growth of scientific understanding, assess current and emerging research trends, and predict future developments in that area. The outcomes are accessible to sponsors and researchers alike[10]. Recent years have seen rapid development in bibliometric analysis and science mapping. This tool is employed in a wide range of research domains due to its helpful method of assessing the merits of a particular publication or specialized subject area[11-16].

There have been some published bibliometric studies in the parasitology field[11-17]. The aim of this study is to conduct a bibliometric analysis of the international PAM literature.

Methodology and Data Acquisition

A bibliometric approach was utilized in this research to examine the PAM research trends. We utilized the term "Primary Amebic Meningoencephalitis" as the keyword in order to retrieve PAM-related documents. The Web of Science (WoS) or Scopus databases are most frequently used in bibliometric analyses[11-16]. In the current study, the WoS database served as our primary data source.

The WoS core collection database was used to extract specific information about the publications, such as the author names, publication years, countries, institutions, and journals. Following is how the inclusion condition was created: TS (Topic):"Primary Amebic Meningoencephalitis," Language: English, content type: research article, and timespan: 1970–2021. The download date was 22 June 2022.

First, during the data preparation step, the search keywords were pre-analyzed to acquire complete and representative data. The data were vetted in accordance with publishing kinds and criteria after the retrieval approach had been decided. The macro-geographical distribution of PAM research in terms of countries and institutions was examined using the depicted network and frequency statistics. The micro-knowledge distribution properties were examined by fields, journals, and authors. The study of the co-occurrence and clustering of keywords then revealed conceptual grounds and research hotspots.

Visualization maps of this study was generated by VOSviewer software (The Centre for Science and Technology Studies, CWTS, Leiden, The Netherlands). This co-occurrence and co-citation tool was created by Eck and Waltman (The Centre for Science and Technology Studies, CWTS, Leiden, The Netherlands)[18]. It has solid features and an easy-to-use interface. VOSviewer is a software tool for visualizing and analyzing bibliometric networks in academic research. It helps to create visual maps representing relationships between authors, journals and keywords etc. This program uses clustering, heat maps and density maps to group similar items together[15,18].

Results

Out of a total of 339 documents retrieved, 244 (71.976%) were journal articles. Out of the 244 articles, the earliest published article was in 1970. The highest number of publications (7.377%) were made in 2021. Over the past 20 years, there has been an increase in the number of publications in PAM research and 47.54 (%) of the articles were published since 2010. 97.131% of the articles related to PAM were published in the journals indexed within the scope of Science Citation Index Expanded, and 97.131% of them were in English. Spanish language (1.230%) was the second preferred language.

The articles were from 34 different research areas, mainly in Microbiology (27.869%), Parasitology (20.902%), and Infectious Diseases (13.115%).

Thirty-nine countries have published in PAM research over the past fifty years. The only country with more than 100 (n=117) articles in PAM research was the United States of America (USA). Mexico ranked 2nd with 21 articles. Other countries with >10 published articles were South Korea (n=19), India (n=17), Australia (n=12) and Spain (n=12). Table 1 summarizes the publications by country. In table 1 showing 15 out of 39 entries, 5 record(s) (2.049%) do not contain data in the field being analyzed.

The CDC is the most productive organization on PAM and has published 16.803% of the PAM articles. The CDC was followed by the University of Ajou and the University of California.

The mostly funding agencies of PAM research United States Department of Health Human Services (HHS) and National Institutes of Health USA. 9.836% of the articles were funded by the HHS. 151 articles (61.885%) did not contain data in the field being analyzed.

The journal with the highest number of articles published was Parasitology Research, which included 5.738 % of the articles (Table 2).

Table 1. Geographical distribution of publications on PAM*

Countries/Regions	Number of publications*	% of 244
The USA	117	47.951
Mexico	21	8.607
South Korea	19	7.787
India	17	6.967
Australia	12	4.918
Spain	12	4.918
France	8	3.279
Belgium	7	2.869
England	7	2.869
Brazil	6	2.459
Pakistan	5	2.049
Türkiye	5	2.049
Peoples Republic of China	4	1.639
Taiwan	4	1.639
Iran	3	1.230

*PAM: Primary amebic meningoencephalitis
* all authors according to their country
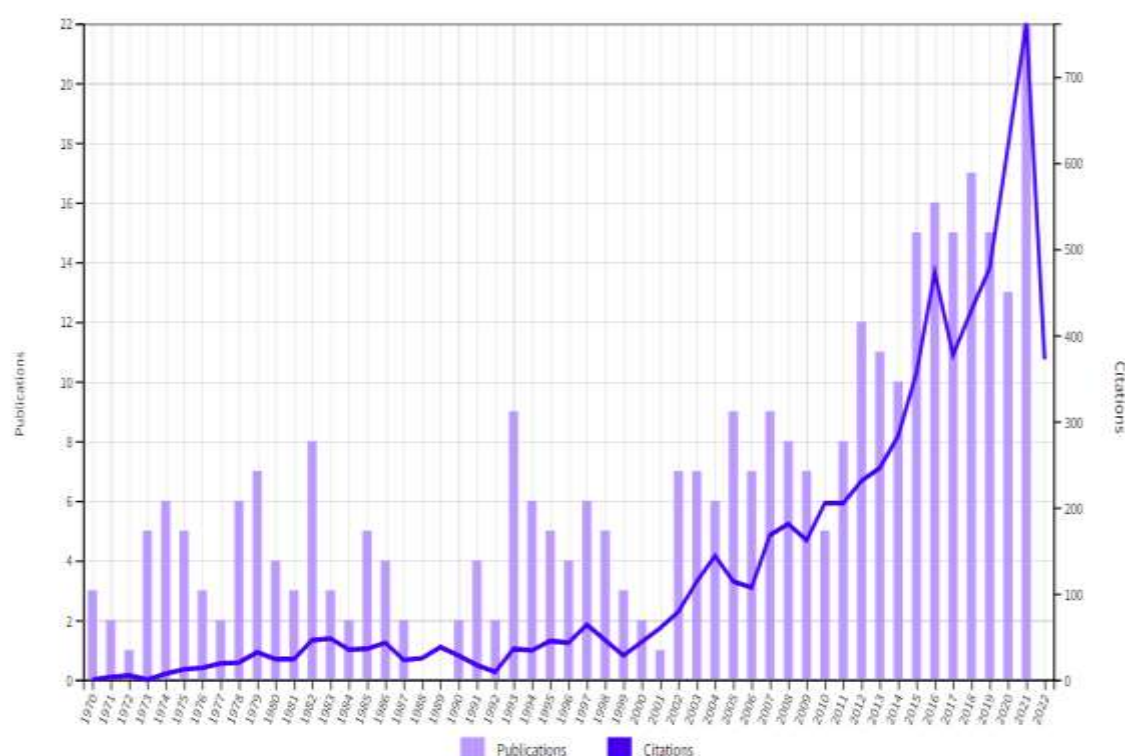
Table 2. The distribution of the output journals

Journals	n	% of 244
Parasitology Research	14	5.738
Journal of Eukaryotic Microbiology	11	4.508
Journal of Clinical Microbiology	8	3.279
Clinical Infectious Diseases	7	2.869
Journal of Parasitology	7	2.869
Experimental Parasitology	6	2.459
Antimicrobial Agents and Chemotherapy	5	2.049
American Journal of Clinical Pathology	4	1.639
American Journal of Tropical Medicine and Hygiene	4	1.639
Applied and Environmental Microbiology	4	1.639
Emerging Infectious Diseases	4	1.639
Korean Journal of Parasitology	4	1.639
Microbiology Sgm	4	1.639
Mmwr Morbidity and Mortality Weekly Report	4	1.639
Parasite Immunology	4	1.639

Showing 15 out of 136 entries

Citing Analysis

These articles had 5240 total citations (4182 without self-citations) (21.48 per article), and the average H index was 37. The citation count has rapidly grown since the 2000s (Figure 1).

117 articles were published in the USA and had 3442 total citations (29.42 per article). Their average H index was 30. 21 articles were published in Mexico. They were cited 416 times (19.81 per article), and the average H index was 12.

Figure 1. The publication and citation summary over the years.

Mapping with VOSViewer

Co-authorship analysis, overlay visualization of countries, and keyword visualization with a minimum of one occurrence were done using the VOSViewer tool (Figure 2-4). Detailed keyword analysis is given in Table 3 and Figure 4. This table presents the keyword analysis of VOSviewer data focusing on PAM. The most important keywords are *'Naegleria fowleri'* and 'PAM', with 'amebic meningoencephalitis', 'free-living ameba' and 'cerebral hernia' related to the main disease and organism. "Other terms such as '*Acanthamoeba*' and *'Acanthamoeba spp.*' are also mentioned. Important treatment, clinical and diagnostic terms include "Amphotericin B", "meningoencephalitis", "immunohistochemistry" and "cerebrospinal fluid". Rare but relevant terms include "*Balamuthia mandrillaris*", "brain-eating amoeba" and "autopsy case".
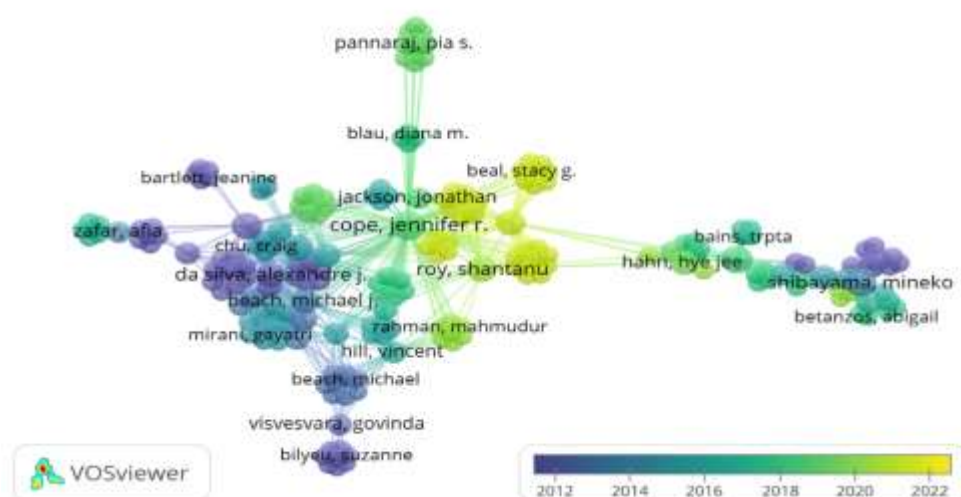

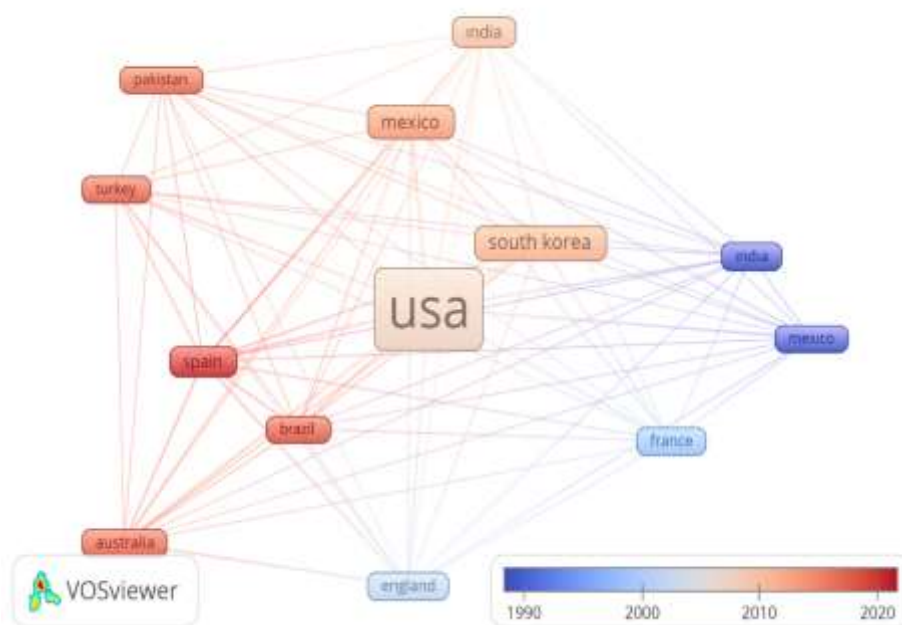**Figure 2. Co authorship analysis (authors minimum with one articles).**

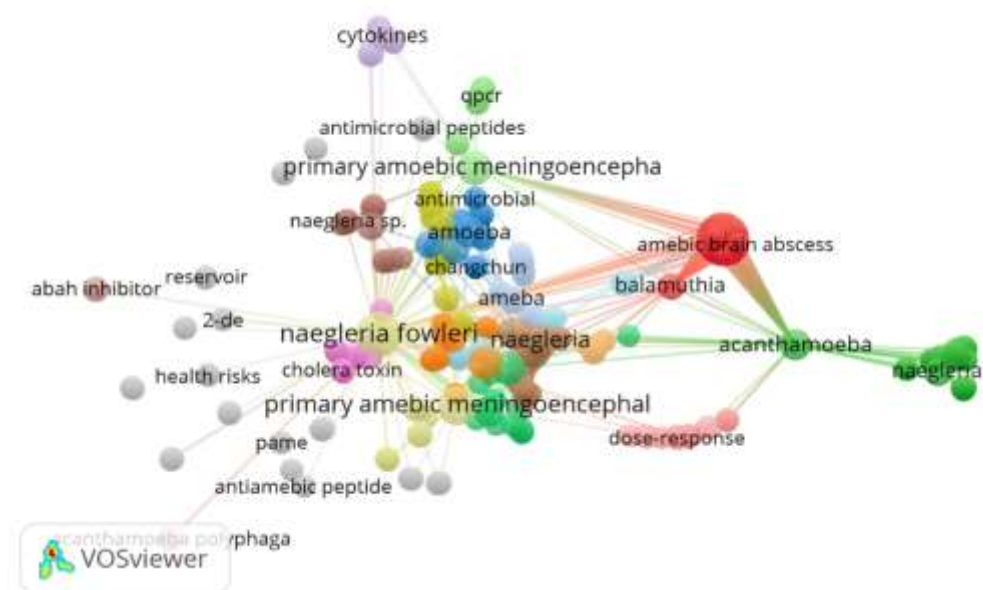**Figure 3. Overlay visualization of countries with minimum 5 articles.**

Figure 4. Keyword visualization with minimum one occurance.

Table 4 presents a co-authorship analysis between countries, revealing the highest influence of the USA in this area with 19 documents and 608 citations. India ranks second with 5 documents and 164 citations, but has a weaker relationship with other countries. Mexico and Nigeria contributed with 3 documents each, but their linking strength is zero. Australia and Belgium contributed one each with 2 documents and 43 citations, but their linkage strengths are weaker. Japan is similar to Australia but has an overall link strength of only 1. Countries like New Zealand, Bangladesh, France, Peru, Spain, and Turkey have lower levels of influence with 1 document each, and Pakistan and China have a link strength of 1.

Table 3. Keyword analysis with Vosviewer

Keyword	Number of occurrences	Total link strength
naegleria fowleri	10	32
primary amebic meningoencephalitis	8	26
amebic meningoencephalitis	3	7
free-living ameba	3	17
amphotericin b	2	7
meningoencephalitis	2	7
pam	2	10
ablution	1	8
acanthameba	1	4
acanthamoeba spp.	1	5
ameba	1	2
autopsy case	1	2
balamuthia mandrillaris	1	4
balamuthia sp.	1	5
brain eating ameba	1	3
central nervous system	1	4

cerebral hernia	1	3
cerebrospinal fluid	1	4
cns protozoal infections	1	2
encephalitis	1	8
genotype	1	8
immunohistochemistry	1	5
meningitis	1	8
miltefosine	1	2
naegleri	1	2
naegleria	1	2
negleria fowleri	1	4
newborn	1	3
ritual rinsing	1	8
survivor	1	2

Table 4. Co authorship analysis between countries

Country	Number of documents*	Number of citations	Total Link Strength
USA	19	608	7
India	5	164	0
Mexico	3	38	4
Nigeria	3	49	0
Australia	2	43	0
Belgium	2	37	3
Japan	2	43	1
New Zealand	2	22	0
Australia	1	16	2
Bangladesh	1	16	2
France	1	1	0
Pakistan	1	90	1
Peoples R China	1	11	0
Peru	1	4	0
Spain	1	10	0
Turkey	1	4	0
India	1	7	0

**according to the first author

Discussion

There have been some published bibliometric studies in the parasitology field[11-17]. However, no bibliometric investigation of international PAM literature exists, and our study is the first bibliometric study on PAM, to the best of our knowledge.

We used various bibliometric approaches and tools to acquire insight in terms of scientific document characteristics, publication dates, subject categories, top journals, geographic distribution, and PAM research trends. The development of the PAM literature was revealed by evaluating the publications related to PAM

in WoS-indexed journals from 1970 to 2021. The findings might serve as a starting point for a clearer understanding of how PAM research has been progressing globally and could stimulate further interest particularly in developing countries.

The CDC has kept a database of PAM cases that have been reported in the USA since 1962[5]. According to the PubMed database, the first reports on PAM was published in 1966[19] and there has been an annual growth of PAM articles since the 1990s. In our study, it is shown that the first article was published in 1970 but over the past 20 years, there has been an increase in the number of publications in PAM research, and 47.54 (%) of the articles have been published since 2010. This difference between databases may be due to the indexing of different journals.

The first PAM cases detected in the USA were in Orlando, Florida and it has been reported that more than half of the 113 PAM cases detected between 1962 and 2009 were in Florida and Texas [5,19]. The PAM cases have occurred in most southern states, including Arizona, Arkansas, Florida, California, Louisiana, Georgia, Mississippi, Missouri, Nevada, New Mexico, North Carolina, Oklahoma, South Carolina, Texas, and Virginia [5]. With the increase in the number of infections reported since 2010, another concern is the changes in the epidemiology of PAM. The first confirmed case of PAM in the north was reported in Minnesota in 2010, and additional cases from Indiana, Minnesota, and Kansas; continued to be reported[20]. So, the risk of PAM infection was not confined to southern states[21]. PAM caused by this warm-weather and potentially climate-sensitive pathogen raised concerns as the geographic range in which cases are seen has increased[20].

Although the studies in this review are spread across five continents, their spatial distribution within those continents is heterogeneous. Only a few hundred articles on PAM, predominantly from the United States, Australia, and Europe as well as certain Asian nations, have been published in 39 countries throughout the world (excluding Antarctica)[22]. PAM is a disease that is more common in developed countries and has recently been reported in developing countries with warmer climates[20]. Recently, an increase in the number of PAM cases has been reported in Asian countries[21]. This heterogeneity in the number of cases may be related to the differences in the importance of PAM in countries, the lack of experience in the diagnosis of PAM, and the differences in the frequency of cases. In addition, the variation in surveillance programs between countries may explain the heterogeneity in the number of cases and, therefore, the number of publications.

47.951% of the published literature on PAM was from the USA and the USA had the highest citation numbers and H index. The number of citations of the articles from the USA demonstrates PAM's influence on their academic communities. It may be due to the fact that PAM cases are reported in the USA and that the CDC follows the cases. The number of publications in Australia, where the first cases were seen[19], was in the fifth rank in terms number of citations. Mexico ranks second after the USA, with a total of 21 publications on PAM[23-26]. A total of 3 research articles on PAM have been published from Iran

The lines represent worldwide collaboration networks, and the width of each line denotes the quantity or number of such connections. In our study, "words co-occurrence network" was created based on the frequency, association, and co-occurrence of each keyword in published documents on PAM

The analysis' findings show that most research societies have already established a linked and tightly knit network of collaboration, especially among the scientifically developed nations.

Conclusion

In this study, the top leading journals, countries, most-cited published papers, and most-relevant authors in publications on PAM from 1970 to 2021 were also analyzed quantitatively and qualitatively. This will make it easier to produce reports, assessments, and visualizations of PAM research outputs that are based on verifiable facts.

In conclusion, due to the high mortality of PAM, it is crucial to diagnose PAM early and take preventive measures. Therefore, it is essential to raise awareness about PAM, especially in developing countries. PAM is more common in developed countries but has also been reported recently in developing countries. However, the number of publications from countries other than the USA is still deficient. The participation

of these countries in research collaboration with non-American countries could be encouraged in this context.

Limitations

This analysis only used items that were indexed in WoS. WoS, however, has several limitations. Not all journals are indexed in WoS. This suggests that additional research is required using a similar database, such as Google Scholar and Scopus from Elsevier (using Harzing's Publish or Perish program). In terms of research output and trends, inclusion of other databases could corroborate and update the study's conclusions. The current study sample was limited to documents exclusively written in English, which is a second limitation. Thus, due to a language requirement, there may be publications on a related subject that were excluded from the study.

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