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Neurocysticercosis research in Mexico: A bibliometric analysis of the Instituto Nacional de Neurología y Neurocirugía Manuel Velasco Suárez

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Neurocysticercosis (NCC) is the most common neglected parasitic disease of the central nervous system and leads to many economic and health issues in endemic and non-endemic countries. A bibliometric analysis would shed light on the evolution and development of research in this field, and this is the first study on NCC research. Our institution in Mexico City, the Instituto Nacional de Neurología y Neurocirugía Manuel Velasco Suárez (INNN), has set some milestones in the management of neurocysticercosis and has a decade-long experience and such an analysis in an endemic country like Mexico will be beneficial. We tracked the scientific output in Scopus, from its foundation to March 2021. The studied variables were article type, number of citations, area (clinical/experimental), chronological profile, and preferred journals. In the period from 1964 to 2021, from a total of 3,166 articles from the institution, 232 papers are related to neurocysticercosis with a total of 7,155 citations. The trending topics in the clinical area are pharmacology and pathology in the experimental papers. The number of articles has steadily increased, but NCC is currently a neglected topic that needs further research to better address the disease burden and allow its eradication.

KEYWORDS

bibliometrics, scientometrics, neurocysticercosis, cysticercosis, taeniasis, taenia solium, Mexico

Introduction

Bibliometrics is a quantitative assessment of scientific research using statistics to better understand the evolution and development of clinical and experimental investigation in the field of study. By pointing at the most frequent topics and the top-cited publications, we highlight the national and/or international trends and patterns and offer an opportunity to elucidate knowledge gaps with key parameters (1–4). Mexico and Latin America have a few bibliometric studies in the field of neurosciences. In Mexico, we have 13 institutions (Institutos Nacionales de Salud (INS), National Institutes of Health), whose purpose is to offer highly specialized medical care services, training to qualified professionals and producing scientific research (4, 5). The Instituto Nacional de Neurología y Neurocirugía Manuel Velasco Suárez (INNN) is a flagship institute dedicated to the neurosciences. As a consequence, it is one of the major health centers treating patients with neurological disorders, including neurocysticercosis (NCC) (6, 7). The foundation of the INNN was planned during the war in the 1940s, but the project was formalized in 1964 by the neurosurgeon Manuel Velasco Suárez (4, 8). Mexican medicine maintains a high prestige within the scientific community in Latin America. Thus, we estimate that a bibliometric analysis from Mexico, specially at the INNN, would provide relevant information about neurocysticercosis research trends. Actually, this is the first bibliometric analysis on neurocysticercosis.

Taeniasis is an intestinal helminth infection generated by different species of tapeworms; however, only *Taenia solium* (*T. solium*) has important repercussions on human health, mainly due to the possible localization of its larvae in the central nervous system (CNS) causing NCC. It is a zoonotic disease that affects humans and pigs, with the latter being the intermediate host in the life cycle of the parasite. Humans become infected with the adult form of the parasite (teniosis), by eating undercooked infected pork containing the larval form of *T. solium*. Both pigs and humans acquire cysticercosis by ingesting eggs, that is, ingesting contaminated food in the cases of humans. Due to its life cycle characteristics, NCC is a marker of poverty and is still endemic in Latin American, Asian, and African countries, in relation with the lack of sanitary infrastructure, poor health education, and persistence of free-range pork production.

According to the World Health Organization (WHO) in 2010, NCC was classified as a neglected tropical disease with approximately 50 million cases worldwide. In fact, it accounts for 50,000 deaths per year and is a frequent cause of epilepsy (around 30%), in endemic countries (9–11). As a neglected tropical disease, we have limited information about incidence and prevalence. With this in mind, a WHO study from 2000 reports that the cysticercosis incidence in Mexico was 0.8 cases per 100,000 per year (12). This has also been seen outside Latin America; a reduction in quality of life has been reported for Asia

(Nepal) and Africa (Cameroon) (13–15). Actually, NCC is one of the most common and prevalent parasitic neurological infections in humans. NCC can be asymptomatic or produce a wide variety of clinical manifestations, epilepsy being the most common followed by hydrocephalus, chronic headaches, vasculitis, chronic arachnoiditis, stroke, and dementia, among others (13, 16–19). The type of manifestation depends on the location, size, number, and stage of development of the cysticerci. The intensity of the inflammatory process also participates in the clinical severity of the disease (16, 19–21).

The main objective of a bibliometric analysis on this neglected tropical disease is to describe the situation of research on NCC from a highly active institution. By describing the areas of interest and the uncharted zones and their evolution, we can highlight the topics where our efforts have to be focused, because they are neglected areas of opportunity. By examining the major themes and historical trends, we can bring out the topics having stood the test of time, whether others can experience peaks and valleys (30). In further studies, we can analyze the patterns of cooperation and elucidate how Latin American research can find partners with interests in the same field (22–26).

Researchers from the South often become the prey of “helicopter research” where those from the North fly in, collect samples, and leave. In a meaningful collaboration, scientists treat local people as partners and think fair instead of charitable when it comes to authorship (27). This study will show the proportion of local research led by local authors and the one where we only “bring additional cases” to a multinational project. No other bibliometric study on NCC has been published to date, and we are filling a knowledge gap.

Methods

As in our previous papers (4, 24, 25, 28), we searched for all scientific articles from the foundation of the institution (1964) to the first quarter of 2021, in the Scopus database, using these MeSH terms: Taeniasis, cysticercosis, neurocysticercosis, tapeworm, and taenia solium. The next step was to classify the studies by type (clinical, experimental). The focus of the papers was also categorized into diagnosis, epidemiology, genetics, epilepsy, pathology, pharmacology, vaccination development, and so on. For the sake of simplicity, if more than two aspects were approached, we considered the paper to the dominant approach. We also include the type of document, year of publication, number of citations, and journal (source) as our variables for analysis. Finally, we divided the papers into three different groups: 1) those definitely that are an institutional initiative (at least 50% of local authors); 2) those where we are leading the project (two authors hold any of these three roles: first, corresponding, or last authors); and 3) the absence of both

criteria seems to prove that we have been invited to someone’s else project.

We also counted the number of citations drawn by this subgroup of institutional papers, as a surrogate marker of the importance of our research as considered by the international community, and analyzing the popularity by subtopic, we can also have an idea of what can be more productive in terms of citations. Bibliometric techniques often praise top-cited or “popular” papers, topics, or authors. However, uncited items shed light on this hidden side of the moon. Thus, we have calculated the percentage of uncited items (L0 index) (4, 28, 29) and compared it to the uncited proportion in the institutional corpus. VOSviewer (Universiteit Leiden, Netherlands, version 1.6.10), a software for bibliometric mapping, was used to analyze our data (coauthorship, word cloud of co-occurrence of terms, etc.).

For the purpose of comparison, we searched the keyword “Neurocysticercosis” restricted to the field “Title-Abstract-Keyword” in Scopus.

Results

The co-occurrence of keywords (MeSH terms) was found using a VOSviewer, as shown in Figure 1. During the study period, the INNN published a total of 3,166 articles; 232 were related to NCC (7.3%). The top-cited article was published in Archives of Internal Medicine “Neurocysticercosis: A New Classification Based on Active and Inactive Forms” (Table 1). From a total of 4,539 papers with “neurocysticercosis” as the prominent topic, 442 were from Mexico. In 2014, a Chinese bibliometric analysis entitled “An analysis on funded theses in the Chinese Journal of Parasitology and

Parasitic Diseases in 2009-2012” reported that 4.2% of their papers deal with cysticercosis (39).

Further specifying the affiliation “INNN,” we found a total of 215 documents, fairly close to the 232 in our database, manually selected from the bulk of all the publications of the INNN. The top three affiliations that have published the most in cooperation with the INNN are Universidad Nacional Autónoma de México (UNAM), Instituto Mexicano del Seguro Social (IMSSm), and Instituto de Diagnóstico y Referencia Epidemiológica (InDRE), all national institutions (Figure 2).

Of the 232 papers, 87% were clinical (202) and 13% were experimental (30). Clinical papers have dominated the scene across all the periods of study. In terms of citations, the top journal was *Archives of Internal Medicine* (797 citations), followed by *Archives of Neurology* (575), *New England Journal of Medicine* (497), *Journal of Neurosurgery* (388), and *Neurology* (365) (Figure 3). The trending topics per year were pathology, epidemiology, symptomatology, treatment, diagnosis, prevention, economy and quality of life pharmacology, pathology, medical treatment, epilepsy, epidemiology, immunodiagnosis, diagnosis, immunology, neurovascular, and hydrocephalus as illustrated in Figure 4. By category, the clinical articles were divided as follows: 137 were classified as original research, 30 as reviews, 12 as letters to the editor, eight as case reports, five as conference papers, three as book chapters, three as editorial, two as short surveys, one as note, and one as erratum. On the other hand, experimental research had 26 original, two reviews, one case report, and one letter to the editor (Figure 5). Furthermore, national journals, number of articles, and their citations per article are shown in Table 2. The most prolific first or corresponding authors by category are observed in Table 3.

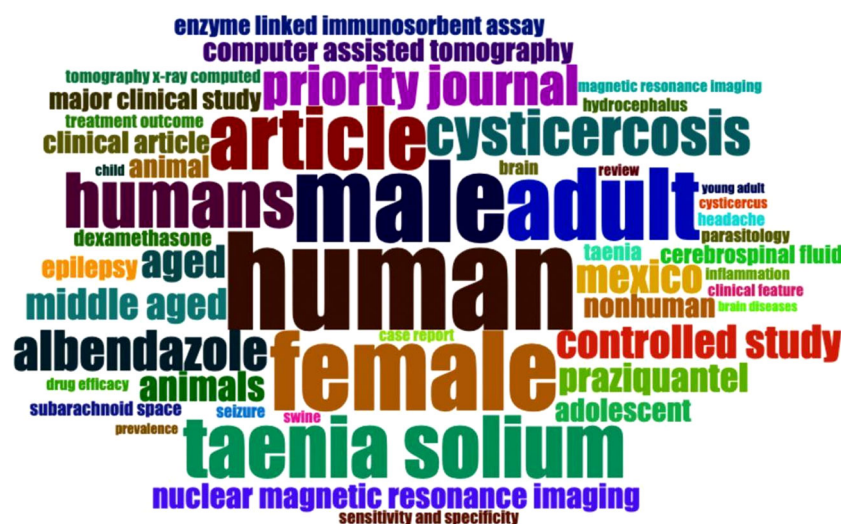


FIGURE 1 VOSviewer visualization of Mexico’s collaboration map with other countries in terms of the world scientific contribution on neurocysticercosis.

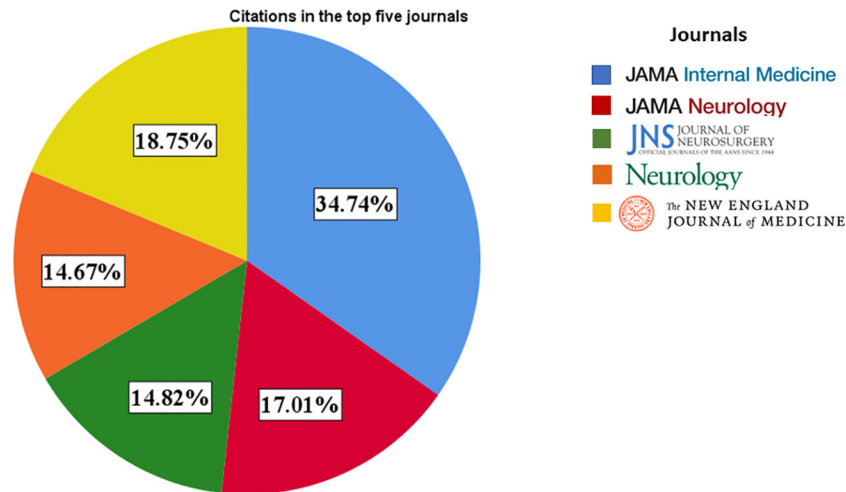


FIGURE 3 Number of citations by Journals. The most prolific five Journals. *Archives of Internal Medicine* with a total of 797 citations, followed by *Archives of Neurology* with 575 cites, *New England Journal of Medicine* with a total of 497 cites, *Journal of Neurosurgery* with 388 cites, and *Neurology* with 365 cites.

our papers were marginal participation in the project of another researcher or from another institution.

Discussion

As in our previous papers, our choice of Scopus was grounded on the wide coverage of sources not covered by other repositories, including the Web of Science (WoS). The

Mexican Science and Technology Journals Classification System is a public policy instrument of the Mexican Science Council (CONACyT), and the proportion of indexation of Mexican journals is 89% in Scopus, 49% in PubMed, and 34% in the WoS Core Collection (40). We included papers whose main topics were *Taenia solium*, neurocysticercosis, and cysticercosis. From 1964 to 2021, the INNN has published 3,166 articles, from which 7.3% (232 articles) are related to NCC, taenia solium, and cysticercosis. In the same period, the INNN has published 228

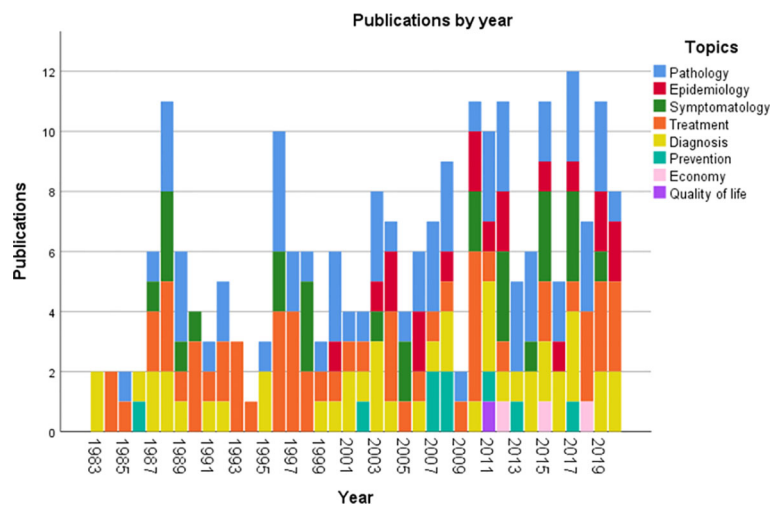


FIGURE 4 Production of the total number of articles per year classified by topics.

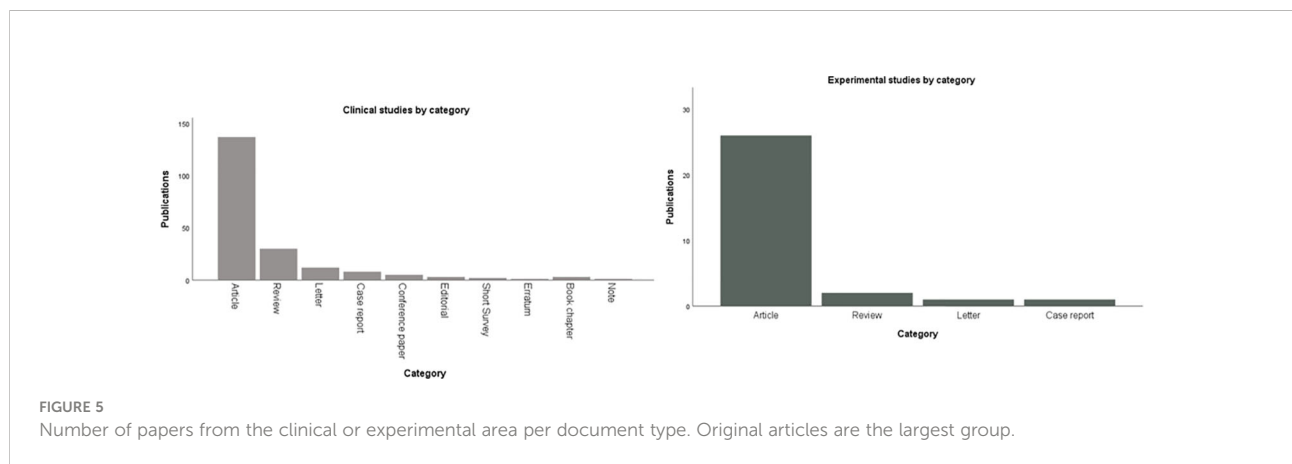


FIGURE 5 Number of papers from the clinical or experimental area per document type. Original articles are the largest group.

TABLE 2 National journals. Number of articles and their citations per article.

	Mexican journals	Number of articles	Number of citations
1	Salud Pública de México	1	13
2	Gaceta Médica de México	4	8
3	Archivos de Neurociencias	6	5
4	Investigación Médica Internacional	1	1
5	Revista Mexicana de Neurociencias	4	0
6	Revista de la facultad de Medicina UNAM	1	0
7	Anales Médicos	1	0

UNAM, Universidad Nacional Autónoma de México.

TABLE 3 Most prolific first/corresponding authors by category.

	Clinical	Percent %	Affiliation	Experimental	Percent %	Affiliation
Author	Sotelo J.	43%	INNN	Palomares F.	53%	INNN
	Fleury, A.	35%	INNN/UNAM	Morales J.	29%	INNN
	Del Brutto Ó.	23%	INNN	Scitutto E.	18%	UNAM
Corresponding	Sotelo J.	43%	INNN	Scitutto E.	44%	INNN
	Fleury, A.	38%	INNN/UNAM	Jung Cook, H.	39%	INNN
	Scitutto E.	19%	UNAM	Flisser, A	17%	UNAM

INNN, Instituto Nacional de Neurología y Neurocirugía; UNAM, Universidad Nacional Autónoma de México.

papers on epilepsy (2), 118 on dementia (33), and 118 on tumors (24). We can therefore see that neurocysticercosis has been and is of great interest for the institution. Furthermore, we can relate NCC with epilepsy, where research is close to the same percentage. Moreover, INNN is a leader in the research in epilepsy and the most cited institution in comparison with the other health institutes in Mexico (2). According to our research, in 1983 the INNN started publishing scientific papers related to NCC, having its peak in 2017. However, in the last few years, the production of articles has slightly decreased, partly due to NCC becoming a neglected disease (29) and the current conditions that the world is going through and that research priorities might have changed (32). Moreover, clinical papers have

predominated over the others with 87% of total published articles, while experimental papers represent 13%. We can therefore see that windows of opportunity are there, because we are still an international reference center and experimental and clinical-experimental are the key to opening new routes for pharmacological or even genetic engineering disruptive treatments. In this scenario, more experimental research might help in better understanding the biomolecular mechanisms of damage (immunopathology), supporting the deleterious effect on human health. This might help in finding tools to counteract or prevent NCC, improving therapeutic strategies and effective medical treatments such as vaccines and effective drugs, and giving early diagnoses with the purpose to help animals and

TABLE 4 Study design of clinical studies.

Study design	N	Percentage
Case report	8	4%
Cases series	10	5%
Cross-sectional	25	12%
Double-blind randomized control trial	1	1%
Non-randomized control trial	12	6%
Randomized control trial	11	6%
Pre and post comparison group	12	6%
Longitudinal observational	55	27%
Prospective longitudinal cohort	14	7%
Retrospective cohort	14	7%
Transversal	14	7%
Ecological	3	2%
No classified	23	11%

TABLE 5 Study design of experimental studies.

Study design	N	Percentage
Longitudinal observational study	2	7%
Case report	2	7%
Cross-sectional	2	7%
Randomized control trial	4	13%
Non-randomized control trial	14	47%
Pre- and post-comparison group	4	13%
No classified	2	7%

humans alike. Subsequently, other studies suggest that the lack of appropriate animal models or *in vitro* to study NCC, cysticercosis, and taeniasis has been a disadvantage for basic research (22, 41). As a result, this could be another reason to explain the lack of information and the need for further research. In contrast, in the case of clinical articles it is understandable why the trending topic and the major number of articles are about pharmacology. In the 1980s, INNN was the first institution describing the use of albendazole and praziquantel, principally for parenchymal NCC that was the main radiological form seen; in consequence, one of the most cited articles is “Therapy of Parenchymal Brain Cysticercosis with Praziquantel” (1984), with 200 citations from *New England Journal of Medicine*. More recently, pharmacology is still one of the most cited and popular topics due to the therapeutic problems that persist in extraparenchymal NCC, the frequenter radiological form seen nowadays at the INNN.

Archives of Internal Medicine published our most cited article “Neurocysticercosis: A New Classification Based on Active and Inactive Forms” (1985; 338 citations); this is a clinical series establishing new diagnostic criteria. Other trending topics are epilepsy, epidemiology, and medical management. Our results highlight other topics which would merit more attention from Mexican researchers: genetics, neurosurgical management, prevention, effects on mental health, and many others. To emphasize on the importance of our study, Mexico represents 7.1% of all the 4,539 research papers on the disease, and the INNN has half of this amount. In fact the Peruvian University Cayetano Heredia (Lima, Peru) has 224 papers, making of the INNN with our record of 232 papers, the first institution in the world publishing on this topic. All the publications listed under a given affiliation are considered as “institutional papers,” but one cannot claim *leadership* if one has

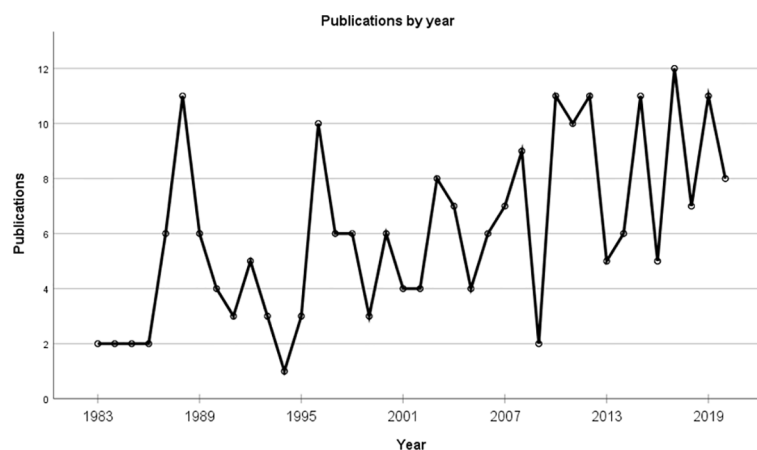


FIGURE 6 Production of the total number of articles per year.

not led a project. In the case of NCC, we can justify that we are leaders. Indeed, in 71% of the NCC papers involving INNN members, two of the three lead authors (first/last/corresponding) were INNN staff. Like in a ceremony, we can only play three roles: the honoree, the staff, or the guests. For further bibliometric analysis of publications of countries not belonging to the “top countries” in research, we propose to adopt our criteria to differentiate “native research” where more than half of the authors are from that country or institution, from “joint venture research” where, while not always representing the majority, the country keeps the leading role (first/last/corresponding) in the partnership and “research as a guest” where the country or institution has only been called to add up numbers (patients), to a research originated elsewhere (namely, in an economically more developed nation). This last situation is not an inglorious position, and it can even give some ideas for some more local innovative projects. However, that is not definitively a project you can claim has having emerged from your own creativity.

Concerning the L0 uncitedness index, our papers had 14%, comparing favorably to 34% in tumors and 21% in epilepsy from the same institution. In lay terms, the proportion of papers judged as “irrelevant” is low, which may suggest that our research on NCC was far more focused on subjects that were of interest for the global scientific community.

As with many other infectious diseases, the academic community should keep an eye on the epidemiological profile which has certainly been modified by the profound economic, societal, and sanitary transformations in our countries. Additionally, the other scientific powers in this field have only a few papers in common with our institution: Brazil, Peru, and India respectively have 12, 8, and 7. Our relationship with Ecuador and France is strong (20 and 19 papers, respectively), because three renowned researchers from those countries have been trained in our institution or are from these countries. We

should develop a long-term cooperation with major institutions from the abovementioned countries to put in common our clinical data and join our efforts in an international crusade against this neglected tropical disease.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Author contributions

All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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