Bibliometric Analysis of Worldwide Publications on Aero-Medical Transport

Aldir Silva Júnior[1]*, Cezar Cheng[2], Roberto CL Silva[1], Clenya RB Lima[3], Viviane RF Silva[1], Beatriz N Bahia[1] and Carlos RL Silva[4]

[1]*Federal University of the State of Rio de Janeiro, Brazil*
[2]*National Cancer Institute, Brazil*
[3]*State University of Roraima, Brazil*
[4]*State University of Rio de Janeiro, Brazil*

*Corresponding Author: Aldir Silva Júnior, Federal University of the State of Rio de Janeiro, Brazil.

Abstract

Introduction: Provide a bibliometric overview of publications on aeromedical transport.

Method: A bibliometric study that approached the production registered electronically in base, from 1946 to 2022, with descriptive statistical analysis.

Results: A total of 258 documents were retrieved, including original articles and reviews, from 725 authors and co-authors, published in 157 journals. The average number of documents per author was 0.356 and the average number of authors per document was 2.81, and the collaboration index was 3.75. Nursing contributed with 54 (20.93%), and Medicine was the most productive area, with 227 (87.98%).

Conclusion: The data presented demonstrates the low level of interest of the scientific community in the subject. It was not possible to identify an elite group of authors. The study shows that there is dispersion in the production of journals. The quantitative contribution of Nursing is insignificant when compared to Medicine.

Keywords: *Air Ambulance; Pre-Hospital Care; Nursing; Aeromedical Transport*

Introduction

In the year 1933, the first aeromedical removal service was established in Austria, which later became the Royal Flying Doctor Service, however, there are reports of the use of balloon for evacuation of soldiers, civilians and wounded to places where they could receive medical attention. This occurred in the Franco-Prussian War (1870 - 1871) with the invasion of Paris [1,2].

With the advent of aero-medical transport in war areas, profound changes in medical care strategies occurred, as there was no longer the need for hospitals to remain in the combat zone: they were then moved to cold (safe) areas, functioning as a base for the removal of the wounded [2].

The insertion of the helicopter, especially in a war environment, has become a key tool in the evacuation of the wounded in conflict areas. In 1962, during the Vietnam War, the helicopter became the best option for military and wounded displacement since it was a scenario of rugged terrain, closed forest and severe epidemics. The most commonly used helicopter was the H1, which usually had two pilots, a stretcher in its internal configuration and a team composed of an auxiliary (doctor or nurse) to rescue the wounded in missions with little security and subjection to enemy artillery [1].

In Brazil, in 1988, the Military Fire Department of Rio de Janeiro State, in association with the General Coordination of Air Operations of the State (GCAO), started a pioneer program of pre-hospital assistance, using rotary wing air service composed, initially, of two mono-turbine aircraft type HB-350: one with a basic configuration manned by a specialized nursing technician (Emergency Medical Technician [EMT]) and a nursing assistant, and another with an advanced configuration composed of a physician and a nursing assistant [3]. This team configuration appeared in the late 80's, however, the current legislation (Resolution COFEN nº 0656/2020) normatizes the nurse's role in direct assistance and management of mobile pre-hospital and inter-hospital care in an air vehicle.

In Brazil, aeromedical evacuation is a free and humanitarian service performed by the Brazilian Air Force and Military Police/Fire Department in the main urban centers of the country. These institutions are responsible for primary removals (at the source of the event/accident), rescue and salvage, and eventually, for secondary removals (after being treated in a hospital unit), i.e. intra-hospital. For this reason, the intra-hospital transport is not the end activity of the institutions mentioned, because there has been a movement of deployment of private aeromedical removal services, performed mainly by air cab companies.

In this scenario, a series of treaties were elaborated in the so-called Geneva Conventions, defining the norms for international laws related to International Humanitarian Law. The treaties, which are the basis of this set of laws, were unprecedented and defined the rights and duties of people, combatants or not, in time of war. In this context, Brazil deserves prominence for its continental dimensions, varied demographic characteristics and densely populated territory [3].

The monitoring of the scientific production on aeromedical transport is highly necessary in order to adopt different policies for health care, especially for citizens who are victims of automobile accidents in areas with dense demographics and/or collapsed urban traffic. Evaluating the productivity of research on this topic is extremely timely. These studies are carried out using bibliometric indicators, which help to identify research trends, research topics on the rise, international collaboration, and the country's contribution to the field [3,4].

Therefore, the objective of this study was to provide a bibliometric overview of publications on aeromedical transport. The focus of this study was on papers published between 1946 and 2022, to give insight into research activity from World War II to the present day in this field and future prospects, in order to help health policy makers make future plans for aero-medical transport more relevant [4].

Bibliometric analysis, based on the application of statistics to bibliography, has three worldwide recognized laws: Bradford's Law (law of dispersion of scientific knowledge), Lotka's Law (law of productivity of authors) and Zipf's Law (frequency of words). The difference between bibliography and bibliometry is that the latter uses, among other methods, most of the time the quantitative, while discursive, to a lesser extent, which gives bibliometry greater objectivity in the evaluation of scientific production. However, bibliometrics is not only concerned with the quantitative aspect, but also with verifying the relevance and impact of authors, journals, institutions, groups or countries in the most diverse areas of knowledge [5-7].

Bibliometric analyses are based on a set of laws and empirical principles whose origins are in information science. Its objective is to study the quantitative aspects of the production of knowledge, its dissemination and the use of available and registered information, allowing researchers in the most diverse areas to evaluate the current state of the sciences, as well as to manage research [7].

This study is justified by investigating the behavior of the scientific production on aero-medical transport, which may contribute to other health researchers or researchers in related areas, since it will show the distribution of production over time, by geographic area and knowledge, the impact of journals, the most productive authors, among other aspects.

Even with a large volume of books in the large health area, there still seems to be little information on the current state of the art of academic research related to this topic, thus motivating to investigate the following question: is the level of productivity of authors and journals on aeromedical transport correlated to the laws and bibliometric principles of authorship and publication intellectual production?

In order to answer this question by using bibliometric metrics, we aim to provide a bibliometric overview of publications on aeromedical transport.

Materials and Methods

This is a bibliometric study that addressed the production/dissemination published between 1972 and 2022 and the use of electronically recorded information in international databases. The principle of bibliometry comprises the use of reliable indicators, which can be defined as parameters used in evaluation processes [7,8].

The information retrieval was performed in the Scopus database, in March 2022, using the descriptors contained in the string: TITLE (air AND ambulances) AND (EXCLUDE (DOCTYPE, "le") OR EXCLUDE (DOCTYPE, "no") OR EXCLUDE (DOCTYPE, "cp")) AND (EXCLUDE (DOCTYPE, "ch") OR EXCLUDE (DOCTYPE, "ed") OR EXCLUDE (DOCTYPE, "bk")) AND (EXCLUDE (DOCTYPE, "sh")).

Scopus was chosen because it is the largest database of abstracts and citations of peer-reviewed literature with bibliometric tools to track analyze and visualize research. Scopus contains more than 22,000 titles from over 5,000 publishers worldwide, covering the fields of Science, Technology, Medicine, Social Sciences and Arts and Humanities. In addition, it contains more than 55 million records dating back to 1823, of which 84% have references dating back to 1996.

For the purpose of this study, only original and review articles published in journals were included in the analysis. The quantitative assessment of the literature on aero-medical transport was performed simply by analyzing the volume of retrieved articles, while the scientific impact of the publication was presented as number of citations per article and number of highly cited articles, as well as the Impact Factor (IF) of the journals publishing the retrieved articles.

Search query validity was tested and confirmed by manually reviewing 10% of the most cited articles in the retrieved data. The manual review was performed by the authors themselves. The analysis of country affiliation in Scopus can give researchers insight into intra- and inter-country collaboration. Single-country publications (SCP) are those representing intra-country collaboration, while multi-country publications (MCP) are those representing cross-country collaboration. Only the top ten ranked countries, institutions and journals were considered.

To visualize the collaboration or co-authorship of countries, VOSviewer was used [9]. Only the top ten ranked countries, institutions and journals were considered. VOSviewer can represent information as density visualization maps or network visualization maps. In this study, we used the density visualization map as cluster density maps. Each cluster represents a group of countries that collaborate most frequently and closely where the countries with the most co-authorships are those with the greatest extent of collaboration. The statistical analyses were processed by the Bibliometrix 3.1 application whose statistical basis is processed by R® and R-Studio®.

Results

The search returned 258 documents with an average of years from publication of 19.5 published documents per year. The average citation per document was 5.07. As for authorship and co-authorship, 725 researchers were reported. As for single-authored documents, 83 (32.17%) documents were counted, therefore, without co-authorship.

The absolute majority of retrieved documents were original research article types, 245 (94.18%) and review articles totaled 13 (5.82%). A total of 12 different languages were found in the retrieved documents. English, 229 (88.75%), was the language most often found. No documents in Portuguese were retrieved. A total of 29 countries contributed to the publication of the retrieved documents.

The growth of publications on aeromedical transport showed a fluctuating pattern in the period studied (Graph 1). However, the growth of publications showed a remarkable increase in the last decade. The average number of publications was approximately four papers per year.
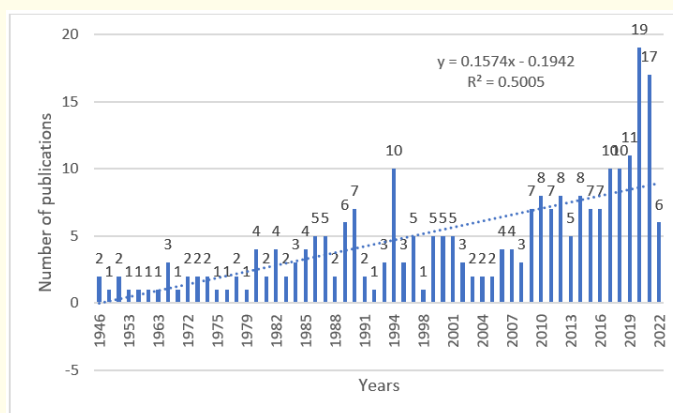
Graph 1: *Growth of publications on aero-medical transport (1946-2022).*

Source: Survey data. Rio de Janeiro, 2022.

Table 1 shows the number of publications and citations per year and the average number of citations per article and year in the time frame studied. The total number of citations of the retrieved documents was 1,789.

Year	Number of articles	Average citation per article	Mean citation per year	Citation per year
1946	2	0.5	0.006578947	76
1947	1	0	0	75
1948	0	0	0	0
1949	0	0	0	0
1950	0	0	0	0
1951	2	0	0	71
1952	0	0	0	0
1953	1	1	0.014492754	69
1954	0	0	0	0
1955	0	0	0	0
1956	1	0	0	66
1957	0	0	0	0
1958	0	0	0	0
1959	0	0	0	0
1960	0	0	0	0
1961	0	0	0	0
1962	1	0	0	60

1963	1	0	0	59
1964	0	0	0	0
1965	0	0	0	0
1966	3	0	0	56
1967	0	0	0	0
1968	0	0	0	0
1969	1	0	0	53
1970	0	0	0	0
1971	0	0	0	0
1972	2	0	0	50
1973	2	0	0	49
1974	2	0.5	0.010416667	48
1975	1	0	0	47
1976	0	0	0	0
1977	1	0	0	45
1978	2	0.5	0.011363636	44
1979	1	0	0	43
1980	4	1.25	0.029761905	42
1981	2	0	0	41
1982	4	6.25	0.15625	40
1983	2	0	0	39
1984	3	1	0.026315789	38
1985	4	11	0.297297297	37
1986	5	1.8	0.05	36
1987	5	0.6	0.017142857	35
1988	2	0	0	34
1989	6	1	0.03030303	33
1990	7	3.285714286	0.102678571	32
1991	2	0	0	31
1992	1	1	0.033333333	30
1993	3	27.33333333	0.942528736	29
1994	10	1.2	0.042857143	28
1995	3	0	0	27
1996	5	7.4	0.284615385	26
1997	0	0	0	0
1998	1	0	0	24
1999	5	3	0.130434783	23
2000	5	2.2	0.1	22
2001	5	8.8	0.419047619	21
2002	3	15	0.75	20
2003	2	2	0.105263158	19
2004	2	9	0.5	18
2005	2	0	0	17
2006	4	19.75	1.234375	16

2007	4	0.75	0.05	15
2008	3	1.333333333	0.095238095	14
2009	7	9	0.692307692	13
2010	8	9.5	0.791666667	12
2011	7	12.28571429	1.116883117	11
2012	8	4.75	0.475	10
2013	5	10.6	1.177777778	9
2014	8	8.875	1.109375	8
2015	7	9	1.285714286	7
2016	7	7.285714286	1.214285714	6
2017	10	9.6	1.92	5
2018	10	4.4	1.1	4
2019	11	6.545454545	2.181818182	3
2020	19	5.894736842	2.947368421	2
2021	17	0.352941176	0.352941176	1
2022	6	0		0

Table 1: Source: Survey data. Rio de Janeiro, 2022.

The VOSviewer technique was used to discover the most commonly found terms in the abstract of the retrieved documents after setting the minimum threshold of occurrences/words at ten. The density visualization map yielded a total of 62 relevant terms distributed in four clusters shown in four different colors (Figure 1).

Figure 1: Cluster visualization map of terms frequently found in the summary of retrieved documents. Source: Survey data. Rio de Janeiro, 2022.

Citation: Aldir Silva Júnior., *et al.* "Bibliometric Analysis of Worldwide Publications on Aero-Medical Transport". *EC Nursing and Healthcare* 4.7 (2022): 78-88.

The top countries that participated in the publication of papers on aeromedical transport were the United States of America (USA), with 181 (69.76%), being the most productive. Figure 2 generated from VOSviewer, shows the map of collaboration by co-authorship among the countries. A minimum of two papers per country and at least a single citation were considered. In all, 19 countries were accounted for.
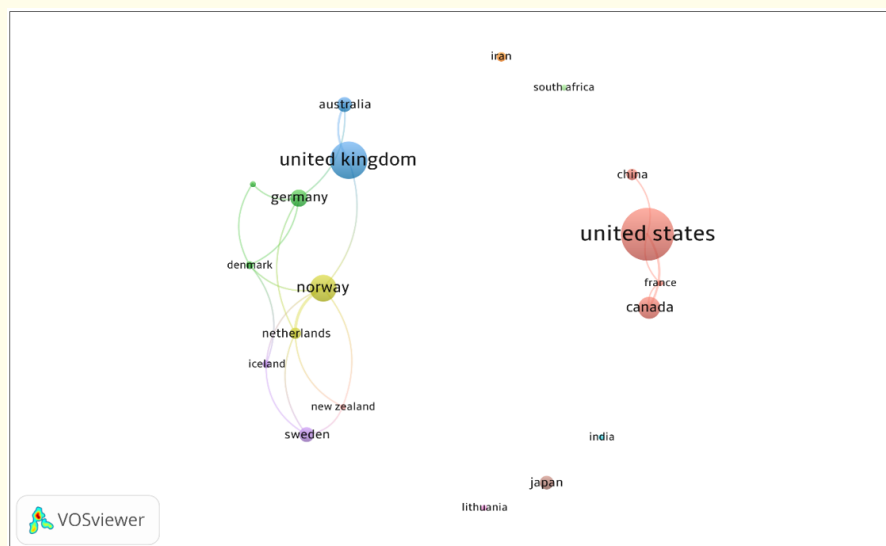
Figure 2: *Map of collaboration among the 19 most relevant countries with at least three documents and at least one citation. Source: Survey data. Rio de Janeiro, 2022.*

The research was done by international collaboration between researchers from other countries. Once again, the United States of America showed its power in the volume of scientific production, this time collaborating with Canada, France, and China. In contrast, European countries, led by the United Kingdom, established greater collaboration with other countries, as can also be seen in figure 2, where countries in the same cluster have greater collaboration than those located far apart in other clusters. In addition, countries with higher number of co-authorships had higher number of articles published on international collaboration.

The most productive author published 14 (0.1%) documents, while 610 authors (84%) published only one document. The average of document per author was 0.356 and author per document was 2.81 and the collaboration index was 3.75. The number of original articles was 245 (94.96%) and the other types of publication accounted for 13 (5.04%).

The geographical distribution of the retrieved publications shows the absolute leadership of the United States of America (USA) with 348 documents (32.3%). Next is Italy with 66 (6.1%); Brazil ranks 13th with 16 (1.4%). The other 50 countries together published 647 articles, which represents 60% of the world production. The geographical analysis of collaboration between countries identified 19 (35.8%) countries. Figure 1 represents the geographic distribution of this collaboration, considering the minimum of two published papers per country.

The retrieved documents were produced by 207 institutions. Nippon Medical School produced the most documents, with 34 documents (13.17%). No Brazilian institution was included in the retrieved data. Colombia is the only representative from South America, with three published documents, representing 1.16% of all production.

Twenty distinct journal areas were identified. Nursing contributed with 54 (20.93%). Regarding the relevance of the journal, those with the greatest impact were the Scandinavian Journal of Trauma and Air Medical Journal, which, even though they are not in the Qualis stratum for the period 2013-2016, have SJR (2020) of 0.95 and 0.3, respectively.

Table 2 summarizes the Bradford Table, with the distribution of the core journals, i.e., those that are contained in Bradford zone 1.

Journal	Rank	Frequency	Accumulated frequency	Bradford's Zone
Air Medical Journal	1	27	27	Zone 1
Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine	2	11	38	Zone 1
Aviation Space and Environmental Medicine	3	7	45	Zone 1
Emergency Medicine Journal	4	7	52	Zone 1
Prehospital Emergency Care	5	7	59	Zone 1
Modern Healthcare	6	5	64	Zone 1
Emergency Medical Services	7	4	68	Zone 1
Hospital Aviation	8	4	72	Zone 1
Canadian Journal of Emergency Medicine	9	3	75	Zone 1
Continuing Care	10	3	78	Zone 1
Environmental Pollution	11	3	81	Zone 1
Injury	12	3	84	Zone 1
International Journal of Emergency Medicine	13	3	87	Zone 1
Air Medical Journal	1	27	27	Zone 1
Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine	2	11	38	Zone 1
Aviation Space and Environmental Medicine	3	7	45	Zone 1

***Table 2:** Bradford table - Zone 1 journals.*

Source: Survey data. Rio de Janeiro, 2022.

Table 3 presents the production by authors according to Lotka's Law. It can be seen that just over 89% of the authors published only a single paper. The authors who produced more than one paper could not approach 50% of the total production. This group produced only 59 documents, approximately 11% of the total of published documents, and it is not possible to admit an elite group of authors for the studied theme.

Published documents	Number of authors	Proportion of authors
1	610	84.1%
2	90	12.4%
3	19	2.6%
4	2	0.3%
5	2	0.3%
6	1	0.1%
14	1	0.1%

***Table 3:** Table of document production proportion by complete authorship.*

Source: Survey data. Rio de Janeiro, 2022.

Discussion

The analyses showed that the research corpus is consistent, because the search strategy and the consequent construction of the data corpus allowed the retrieval of documents from the main descriptors contained in the string, delimiting the subject matter of the research.

A rather irregular distribution of publications was observed, with a peak starting in 2020. The equation and the result of "R" present in graph 1 are 0.5005, which demonstrates that there was dispersion in the productivity of the journals, unlike the 2019 study, which analyzed peripheral venous catheterization [9], showing low productivity and much dispersion, with a mean of 4.953 articles per year, while this study reached 12.2 of mean, therefore, almost three times more.

There was negligible productivity from the 725 authors. The most productive author, Dr. Nolan B, published only six papers, representing 2.32% of the total published papers, while 610 authors (84%) published only one. This result is close to that of the previously cited study. The same occurred with the coauthorship index, 5.45 in the 2019 study and 3.75 in this study, both within the average allowed in most national and international journals of a maximum of six authors per paper.

It is quite reasonable to infer that the low rate of co-authorship is most likely due to the low relevance of the subject in scientific publications and this finding is reinforced when the square root ($\sqrt{n}$) of the number of authors (n) was calculated, as recommended by Lotka and Price's Law for the identification of an elite group in the production of articles on a given theme/subject [10,11].

The value found was approximately 27 authors. For there to be an established elite group, the Law of Elitism (Lotka/Price) [5,6] determines that members belonging to this group should produce at least 60% of the publications, in this study, the equivalent of approximately 155 articles. However, the empirical data showed that the top 27 authors, who should be part of the elite, published only 34 articles, representing only 13.17% of the publications.

In this case, the non-determination of an elite group in the empirical data may be associated with the high number of occasional authors, suggesting weak consolidation of the theme with the specific area of Pediatrics or even possible state of obsolescence of scientific literature, since the study considered more than 50 years of production (1946-2022).

The analysis of co-authorship makes it possible to verify scientific collaboration, which is one of the most researched variables in Social Network Analysis (SNA), since it can provide the researcher with a broad view of the invisible colleges in which the vertices of the research are immersed, as well as a series of other findings regarding the bonding relationships in the scientific field [8,9,12].

In this case, when the average number of co-authors is compared with the institutions and countries of origin, it is possible to verify that the SNA, in the scientific field, is limited to authors whose affiliation is the same for the most part, with the exception of the United States of America and the United Kingdom, which together formed the largest network of inter-country collaboration.

The language of the publications was dominated by English. This dominance can be easily explained by the fact that English is a universal language for science. No Latin American country has networks with the countries represented in the collaboration map. This observation allows us to safely infer that the level of international interaction between Brazilian researchers and those from the other countries that did not form networks/links, even after 50 years of scientific publication on aero-medical transport, remains very fragile. There was no institution that stood out quantitatively.

By applying Bradford's Law to verify the behavior of the distribution/dispersion of the journals (whose statement is: by building a table in descending order of the production of journals on a given subject, it will be possible to distinguish a core of journals more devoted

to the studied subject and several groups/zones with the same number of articles as the core, but with a greater number of journals in the proportion of (Zone 1 = Y), (Zone 2 = 3Y) and (Zone 3 = 3Y2)) [6-9,13] it is possible to see that the Bradford Zone 1 journals are, in fact, those that represent the core of the journals most devoted to aeromedical transport, despite the low dispersion of production, which may indicate that the subject studied has little interest in research and/or scientific publication.

When considering the time spent registering the subject on the Scopus database, it is possible to infer that the subject has already reached maturity and is in a state of production obsolescence, perhaps because it no longer holds the interest of the scientific community and/or the journals, despite the fact that some are extremely specific, however, do not present production in considerable quantity that can demonstrate the importance/relevance of the subject.

Conclusion

The study dealt with the analysis of 258 documents retrieved from the Scopus database, in the period 1946-2022, mostly international, with no Brazilian vehicles, which may indicate low productivity of Brazilian researchers on the subject or even high thematic specificity, as little possibility of citations.

It was possible to show the evolution of the number of publications over more than 50 years, the origin of the articles, which journals published the most on the subject, the impact factor and the geographic location.

As for the authors, it was evident that there was an inexpressive number of authors per article and, as for the most productive, the study highlighted the journal that published their research, the institution to which they are linked and their geographic location. In this regard, it is evident that the subject does not seem to arouse the interest of researchers to the point of forming collaboration networks between countries and institutions.

Although based on empirical facts, Bradford and Lotka's laws were able, in this study, to confirm possible theoretical hypotheses that the core of journals is formed by the most devoted and therefore the most productive. Nevertheless, it was revealed that the more specific the subject/theme, the more limited the possibility of identifying elite groups of authors.

Another important aspect that needs to be considered refers to the cognitive institutionalization of the domain knowledge areas of the retrieved articles and journals, which could be identified by the string used. Even using the grammatical standardization of the descriptors by means of controlled vocabulary (DECs), even so the realization of unreliable inferences can be configured as a limitation of this study.

Patents

This section is not mandatory but may be added if there are patents resulting from the work reported in this manuscript.

Author Contributions

"Conceptualization, ASJ and CRLS; methodology, CRLS; CC and CRBL; formal analysis, CRLS, RCLS, VRFS and BNB writing-review and editing, ASJ and CRLS. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

In this section, please provide details regarding where data supporting reported results can be found, including links to publicly archived datasets analyzed or generated during the study. Please refer to suggested Data Availability Statements in section "MDPI Research Data Policies" at https://www.mdpi.com/ethics. If the study did not report any data, you might add "Not applicable" here.

Conflicts of Interest

The authors declare no conflict of interest.

Bibliography

1. Flexer M. "The helicopter ambulance service". *Hospital Program* 61 (1980): 66-71.

2. Grimes M and Manson J. "Evolution of flight nursing and the national flight nurses association". *Journal of Air Medical Transport* 10 (1991): 19-22.

3. Mannarino L. ""Transporte pré-hospitalar e aeromédico no trauma". In Compendio de trauma. Freire, E. Atheneu: Rio de Janeiro, Brazil 2 (2001): 35-45.

4. Marcias-Chapula CA. "Opapel da informetria e da cienciometria e sua perspectiva nacional e internacional". *Ciênc Inf* 27 (1998): 134-140.

5. Araújo CA. "Bibliometria: evolução histórica e questões atuais". *Em Questão* 15 (2006): 11-32.

6. Barreto ML. "The challenge of assessing the impact of science beyond bibliometrics". *Revista de Saúde Pública* 47 (2013): 834-837.

7. Medeiros JMG and Vitoriano MAV. "A evolução da bibliometria e sua interdisciplinaridade na produção científica brasileira". *RDCBI* 13 (2015): 491-503.

8. Silva VRF., *et al*. "Análise bibliométrica de artigos sobre cateterização venosa periférica em pediatria". *Cogitare Enfermagem* 24 (2019): e59232.

9. Van Eck NJ and Waltman L. "VOSviewer Manual - version 1.5.4". Univeristeit Leiden: Leiden, Netherlands (2013).

10. Areias FZ., *et al*. "Análise bibliométrica de artigos sobre laringectomia total". *Revista Baiana de Enfermagem* 30.3 (2016): 1-10.

11. Pinto CIC., *et al*. "Scientific production on workplace bullying/harassment in dissertations and theses in the Brazilian scenario". *Revista da Escola de Enfermagem da USP - SciELO* 49.2 (2015): 267-276.

12. Cheng C., *et al*. "Behavior of scientific production on severe acute respiratory syndrome". *Open Science Journal* 5.2 (2020): 1-10.

13. Cortez ACL., *et al*. Entrenamiento de flexibilidad en osteoporosis anterior: un análisis bibliométrico 20.2 (2020): 1-6.