BIBLIOMETRIC ANALYSIS OF LITERATURE RELATING TO NOISE POLLUTION REPORTED OVER THE PERIOD 2001-2020

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Keywords: noise pollution, noise, traffic noise.

Introduction. *In the new globalized world, noise pollution has started to become a public health problem. Health issues from noise pollution include hearing problems, cardiovascular disorders, and sleep disturbances.*

Material and methods. *We searched for publications about noise pollution in the Web of Science database. A total of 2722 papers were identified, published between 2001 and 2020, 1815 of them were analyzed. VOSviewer (version 1.6.11) tool was used for bibliometric web visualizations.*

Results. *When a trend analysis was applied to the articles by year, a statistically significant increase was detected. The United States contributed to the most publications (15.3%). Scotland (6.62), Singapore (4.26), and Ireland (4.02), to the most frequent publications per million of inhabitants. Most articles on noise pollution were published in the journal Applied Acoustics (3.2%). The three keywords we used were "noise pollution", "noise" and "traffic noise".*

Conclusions. *This study showed that there has been a trend of an increasing number of articles on noise pollution in the last 20 years, also it can be considered that this bibliometric study will help researchers as it provides summary for current research.*

Cuvinte-cheie: poluare fonică, zgomot, zgomot din trafic.

ANALIZA BIBLIOMETRICĂ A LITERATURII PRIVIND POLUAREA FONICĂ, RAPORTATĂ ÎN PERIOADA 2001–2020

Introducere. *În noul context al unei lumi globalizate, poluarea fonică tinde să devină o amenințare pentru sănătatea publică. Problemele de sănătate, cauzate de poluarea fonică, includ probleme de auz, dereglări cardiovasculare şi tulburări de somn.*

Material şi metode. *Am căutat publicaţii despre poluarea fonică în baza de date Web of Science. Au fost identificate în total 2722 de lucrări, publicate între 2001 şi 2020, dintre care au fost analizate 1815. Instrumentul VOSviewer (versiunea 1.6.11) a fost folosit pentru vizualizările web bibliometrice.*

Rezultate. *Analizându-se tendinţele articolelor apărute anual, s-a constatat o creştere semnificativă statistic. Statele Unite au contribuit cu cele mai multe publicaţii (15,3%). Scoţia (6,62), Singapore (4,26) şi Irlanda (4,02), cu cele mai frecvente publicaţii la un milion de locuitori. Cele mai multe articole despre poluarea fonică au fost publicate în revista Applied Acoustics (3,2%). Cele trei cuvinte-cheie, pe care le-am folosit, au fost „poluare sonoră", „zgomot" şi „zgomot din trafic".*

Concluzii. *Studiul a demonstrat că există o tendinţă de creştere a numărului de articole despre poluarea fonică în ultimii 20 de ani. Putem considera acest studiu bibliometric un suport eficient pentru cercetătorii din domeniu, întrucât pune la dispoziţie un rezumat care facilitează cercetările curente.*

INTRODUCTION

Noise is defined as a disturbing and irritating mixture of loud sounds which can cause temporary or permanent damage to humans and animals (1). The World Health Organization (WHO) has declared noise pollution to be the third most dangerous type of environmental pollutant after air and water pollution (2).

All countries, especially developing countries, are affected by many pollutants in the environment as a result of urbanization and industrialization (3). Noise pollution has increased in intensity with the rise in the industry since the industrial revolution, and with the rise of human activities a rapid urbanization increased with a consequent significant deterioration of exposed population health status. This rapid increase in industrialization, urbanization, and transportation systems has led to currently high levels of noise pollution. Most epidemiological studies have found that road traffic and communities are specifically the main sources of the noise pollution (4-7).

The recent literature focused on noise is important because it demonstrates that annoyance and disturbance due to noise are associated with a high incidence of diseases through harm to human health (8). Noise can cause auditory and non-auditory health effects, both psychological and physiological, and evidence for non-auditory effects was increasing in more recent years (4). According to WHO (2012) report, noise pollution can cause health problems such as cardiovascular diseases, cognitive impairment, sleep disturbance, tinnitus, and discomfort. Increased noise sensitivity can lead to psychiatric disorders such as anxiety and depression (9). Generally, human-generated noise also has a deleterious impact on natural life and has become an ecological pollutant as well (10).

Bibliometrics is the statistical analysis of scientific publications, about a specific topic or research field and disclosing the most effective publications, countries, authors, collaborations between institutions, and active journals (11, 12). Furthermore, it presents the summarized data and enables researchers to evaluate the current trends of the data (13). In addition to statistics, bibliometric indicators can provide insight into research implications, knowledge networks, and information distribution, which saves readers and writers time in terms of literature review by providing a summary of the literature (14).

The present study adopted a scientific analysis through the Web of Science (WoS) database to provide researchers and practitioners with an advanced review of noise pollutant-related studies. This method has the advantages of information retrieval as a whole to highlight the progression, hotspots, and boundaries of publications.

In this study, bibliometric analysis was conducted using newly developed visualization tools (e.g. VOSviewer) to map the global research status and vanguard trends of Public and Environmental Health research from multiple perspectives.

MATERIAL AND METHODS

The methodology of this study was planned with reference to similar studies in the literature (11, 13, 15).

Data sources

Bibliometric data were collected from the Web of Science (WoS) database platform. The literature review was performed using "noise pollution" as the keyword in the Title search section. The articles meeting the criteria were downloaded from the WoS database (access date: 19.08.2021) and analyzed using bibliometric methods.

The date range was set as January 2001 to December 2020. The document type included the articles and reviews. Proceeding paper, book chapter, editorial materials, meeting abstract, letter, and other document types were excluded from the study. VOSviewer was used to visualize the studies and form a network map of references, keywords, and citations. Bibliometric web visualizations were made using the VOSviewer (version 1.6.11). VOSviewer is a widely used software tool presenting visualization maps with connections by combining items such as countries, authors, journals, or keywords. The lines between the items and the thickness of the lines indicate the strength of the connection between them and clustering between items is also shown.

Countries that were the sources of at least 1% of the total number of articles in the date range included in our study were accepted as the main active countries (16). Analysis was performed by finding the total number of articles, the number of articles per million population, gross domestic product per capita ($) (accessed from

https://www.cia.gov/the-worldfactbook/countries/'website), total citations, average citations, and h index values for each country. The Science Citation Index Expanded (SCIE) and Emerging Sources Citation Index data of the analyzed articles were recorded.

Data analyses

The data obtained in the study were analyzed using SPSS vn.15 software (Statistical Package for Social Sciences, version 15, SPSS Inc., Chicago, IL, USA). Values were given as frequency and percentage. Regression analysis was performed to determine the trend of the number of published articles by years. The statistical significance level was accepted as 0.05.

RESULTS

Using the WoS database, a total of 2722 papers were identified published between January 2001 and December 2020. After the exclusion of non-

original articles and non-review papers, 1905 papers remained, then in the second stage, papers not in English language or not directly relating to noise pollution were excluded, leaving a total of 1815 papers for our sample. The journal index distribution of the published articles was as follows: Science Citation Index Expanded (1415), Social Sciences Citation Index (119), Emerging Sources Citation Index (227), Book Citation Index–Science (37), Book Citation Index-Social Sciences and Humanities (11), and Arts and Humanities Citation Index (7).

When regression analysis was applied to the number of articles by year, a statistically significant increase was detected, from 16 in 2001 to 302 in 2020, showing an 18.9-fold increase (p<0.001). In the research, it was seen that there was an increasing trend in the number of articles over the years. The distribution of the number of articles by year is shown in Figure 1.
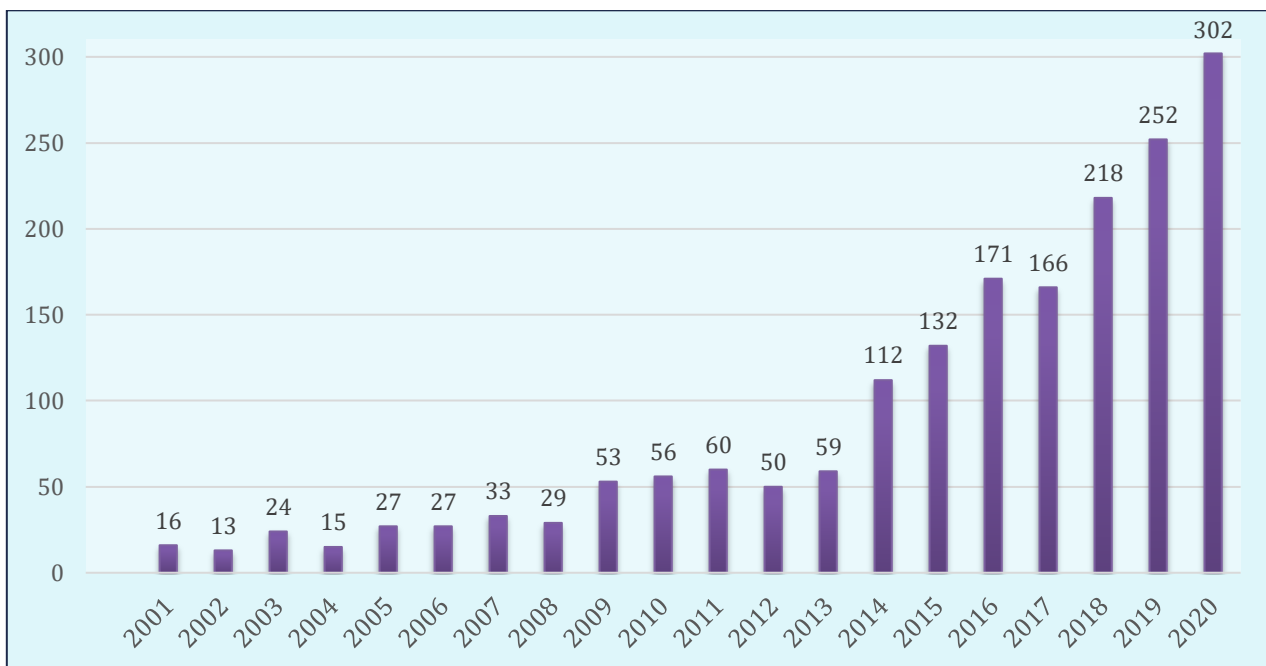

Figure 1. The distribution of papers by year and frequency, related to noise pollution.

The five most cited articles on noise pollution were listed. The authors of these articles were respectively, Stansfeld S.A. et al. (500 citations), Miedema H.M.E. et al. (458 citations), Francis Clinton D. et al. (329 citations), De Nazelle Audrey et al. (320 citations), and Rowe D. Bradley (308 citations) (tab. 1).

The co-authorship author's network map is shown in Figures 2-5.

The number of articles by country, number of articles per million population of productive countries, gross domestic product per capita ($) values of countries, total citations, average citation values, and adjusted h index values for each country are shown in Table 2.

Table 1. Top-10 most commonly-cited articles related to noise pollution.

Rank	Article Title	Authors	Institution	Journal	Year	C	CPY	JIFS
1	Noise pollution: non-auditory effects on health	Stansfeld S.A. et al.	Uni of London Queen Mary	*British Medical Bulletin*	2003	500	27.8	2.804
2	Annoyance from transportation noise: Relationships with exposure metrics DNL and DENL and their confidence intervals	Miedema H.M.E. et al.	Netherlands Organization Applied Science Research	*Environmental Health Perspectives*	2001	458	22.9	8.049
3	Noise pollution changes avian communities and species interactions	Francis Clinton D. et al.	Uni of Colorado	*Current Biology*	2009	329	27.4	9.193
4	Improving health through policies that promote active travel: A review of evidence to support integrated health impact assessment	De Nazelle Audrey et al.	Uni Pompeu Fabra	*Environment International*	2011	320	32	7.943
5	Green roofs as a means of pollution abatement	Rowe D. Bradley	Uni Michigan State	*Environmental Pollution*	2011	308	30.8	5.714
6	How and why environmental noise impacts animals: an integrative, mechanistic review	Kight Caitlin R. et al.	Uni of Exeter	*Ecology Letters*	2011	292	29.2	8.699
7	A synthesis of two decades of research documenting the effects of noise on wildlife	Shannon Graeme et al.	Uni Colorado State	*Biological Reviews*	2016	275	55	10.288
8	Potential public health hazards, exposures and health effects from unconventional natural gas development	Adgate John L. et al.	Uni Colorado Denver	*Environmental Science & Technology*	2014	272	38.8	7.149
9	Triboelectrification-based organic film nanogenerator for acoustic energy harvesting and self-powered active acoustic sensing	Yang Jin et al.	Georgia Institute of Technology	*Acs Nano*	2014	256	36.6	13.903
10	Environmental impact of wind energy	Saidur R. et al.	Uni Malaya	*Renewable & Sustainable Energy Reviews*	2011	251	25.1	10.556

JIFS: Journal impact factor score 2018; C: citations; CPY: citations per year

A significant percentage of the articles were from the USA (15.317%) and China (14.490%). The countries with the most articles per million population were determined to be Scotland (6.63), Singapore (4.26), and Ireland (4.02), respectively. In terms of the average number of citations, the top three countries were the Netherlands (44.96), Switzerland (39.90), and England (31.09).

Figure 2. Co-authorship authors network visualization map.

Figure 3. Co-authorship country network visualization map.

Figure 4. Author keywords co-occurrence network visualization map.

Figure 5. Bibliographic coupling of journals network visualization map.

For countries with a minimum of five papers, a country co-authorship visualization map was created in the VOSviewer application. From a total of 109 countries, 55 countries produced more than five publications. The visualization map of these countries with a minimum number of five papers can be seen in Figure 3.

According to Table 3, the three most used keywords used in the articles were noise pollution (25.179%), noise (9.531%), and traffic noise (3.746%). A visualization was created for the most common keywords determined in the study. The network visualization map for a total of 51 keywords processed from the minimum 10 keywords of all the articles is shown in Figure 4.

Most articles on noise pollution were published in the journal *Applied Acoustics* (58 articles; 3.196%). The 10 most active journals on this subject are shown in Table 4.

The most cited journals were mapped, by creating a citation source network visualization map. The minimum number for this visualization was taken as five articles (fig. 5).

DISCUSSIONS

The bibliometric analysis surveys the contributions of authors, countries, journals, and institutions in scientific studies, and can define the power of scientific impact by showing citations. Bibliometric software such as Gephi, Leximancer, VOSviewer, Scopus, and Web of Science has made it relatively easy to acquire large volumes of bibliometric data and enable the analysis of such data in a very pragmatic way, thereby raising scholarly interest in bibliometric analysis in recent years (17). In the current study, after the application of all inclusion and exclusion criteria, evaluations were made of 1815 articles published between 2001 and 2020 in the WoS database, and the findings and trends on noise pollution were presented. The study data included the number of publications by year, the number of citations, author, institution, journal, and country collaborations, the display of frequently used keywords, and the trend by year.

Table 2. Distribution of the number of publications, gross domestic product per capita
and citation values by country.

Country	n (%)	n*	n**	TC	AC	H-index
United States	278 (15.317)	0.83	62.530	7958	28.63	45
China	263 (14.490)	0.19	16.117	3388	12.88	31
India	140 (7.713)	0.10	6.700	1330	9.5	20
England	137 (7.548)	2.42	46.659	4259	31.09	32
Spain	115 (6.336)	2.44	40.903	2395	20.83	26
Iran	110 (6.061)	1.28	12.389	714	6.49	15
Italy	97 (5.344)	1.55	42.492	1537	15.85	22
Germany	84 (4.628)	1.05	53.919	1976	23.52	25
Canada	76 (4.187)	2.00	49.031	1847	24.3	19
Australia	72 (3.967)	2.79	49.854	1031	14.32	19
Brazil	68 (3.747)	0.32	14.652	1140	16.76	19
Turkey	64 (3.526)	0.78	28.424	560	8.75	13
Netherlands	53 (2.920)	3.06	56.935	2383	44.96	21
France	52 (2.865)	0.76	46.184	1394	26.81	17
Romania	42 (2.314)	1.98	29.941	137	3.26	7
Scotland	36 (1.983)	6.62	46.659	698	19.39	16
Belgium	35 (1.928)	2.97	51.934	735	21	14
Pakistan	28 (1.543)	0.12	4.690	243	8.68	6
Greece	26 (1.433)	2.45	29.799	585	22.5	10
Poland	26 (1.433)	0.68	33.221	183	7.04	7
Singapore	25 (1.377)	4.26	97,341	325	13	9
South Korea	25 (1.377)	0.48	42.765	377	15.08	10
Switzerland	25 (1.377)	2.96	68.628	988	39.52	13
Japan	24 (1.322)	0.19	41.429	267	11.13	10
Malaysia	24 (1.322)	0.72	28.364	599	24.96	8
Portugal	24 (1.322)	2.34	34.894	373	15.54	10
Ireland	21 (1.156)	4.02	86.781	526	25.05	8

n^* : number of articles per million population; n^{**} : Gross domestic product per capita ($); TC: Total citations; AC: Average citations

Table 3. Top 10 high-frequency keywords.

Keywords	Frequency	%
Noise pollution	457	25.179
Noise	173	9.531
Traffic noise	68	3.746
Air pollution	57	3.140
Anthropogenic noise	56	3.085
Urbanization	38	2.094
Road traffic noise	37	2.036
Noise mapping	33	1.818
Pollution	33	1.818
Soundcape	31	1.708

Table 4. The top 10 journals of research on noise pollution.

Journals	Frequency	%
Applied Acoustics	58	3.196
Sustainability	31	1.708
Environmental Monitoring and Assessment	30	1.653
Journal of the Acoustical Society of America	28	1.543
Science of the Total Environment	27	1.488
Transportation Research Part D Transport and Environment	26	1.433
Marine Pollution Bulletin	24	1.322
International Journal of Environmental Research and Public Health	22	1.212
Noise Health	20	1.102
Sensors	20	1.102

There was determined to have been an increase in published articles in the last few years. It can be assumed that this will lead to the future publication of more papers on the research topic of noise pollution as an environmental and public health issue. The most cited articles spearhead the research topic. The authors of the top five most cited articles on noise pollution were Stansfeld SA, Miedema HME, Francis Clinton D, De Nazelle Audrey, and Rowe D. Bradley researchers should focus on these papers and the other most cited papers for further studies.

Although there were 109 countries publishing on noise pollution, the publication of 5 or more articles originated from only 55 countries.

The countries publishing the most articles were seen to be the USA, China, and India, in terms of articles per million population the leading countries were Scotland, Singapore, and Ireland, and in terms of the average number of citations, the top 3 countries were the Netherlands, Switzerland, and England. With their higher populations, China and India were ranked in the top three countries producing more articles in total was expected. The other country with the highest number of articles was the USA, which was not surprising as the USA is the leading country producing studies on many other topics (16, 18, 19). In addition to Scotland (GDP= $30,560), it was quite remarkable that Singapore (GDP=$97,341) and Ireland (GDP=$86,781) the two countries with the highest GDP per capita values, were the top 3 countries that published the most articles per million population.

This showed that there is a strong relationship between the level of economic development and the number of articles per million population within the main active countries. These relatively small countries had given weight to the publication of scientific articles. The relationship between the high-income level and the number of published articles has also been shown in previous studies (11, 13). In addition to traffic and urbanization, costly studies such as the creation of noise maps may have been effective in bringing developed countries to the fore on noise pollution. The Netherlands, Switzerland, and England are more cited due to their leading aspect in scientific studies as well as being developed countries and are considered to be the countries with the most impact per article. These countries are also European countries, and these European countries were able to demonstrate the importance of publication quality with the high numbers of average citations.

Traffic noise, road traffic noise, and urbanization were determined to be among the most used keywords, showing the effect of urbanization and traffic noise. In addition, the keywords of pollution, air pollution, and environmental noise indicate that noise is considered as an environmental problem. Anthropogenic noise keywords show that the effect of noise on the ecological natural environment and animals is a unique research area. The noise map keyword was one of the most used keywords, which demonstrated that noise mapping is also an important research area for noise pollution. However, creating a noise map for an area can be costly, so in developing or underdeveloped countries, in particular, R&D studies should be structured or accelerated to support global noise pollution scientific studies and the generation of noise maps.

Most articles on noise pollution were observed to be in *Applied Acoustics, Sustainability, Environmental Monitoring, and Assessment* journals but noise pollution articles in these journals constitute a relatively small proportion of all noise pollution articles (16-21). Although the top 10 journals that have published the most articles are shown in this study, it would be appropriate to recommend that researchers also review other journals.

This study presented a bibliometric analysis of noise pollution extracted from the Web of Science database. Although the study was as comprehensive, systematic, and objective as possible, there were also some limitations. The most important of the limitations was the use of only the WoS database. More comprehensive databases such as Pubmed, Google scholar, or Scopus could have been included. However, the WoS is conspicuous as the most widely used reliable database in bibliometric studies. Other limitations were that only articles in English were included, and searches at different times could increase the number of citations, especially for more recent articles. However, the study included articles that examined the effects of noise pollution not only on humans but also on animals. This subtle approach provided the opportunity to examine the effects of noise pollution more comprehensively.

CONCLUSIONS

1. The results of this study showed that there has been an increasing trend of articles on noise pollution in recent years.

2. The United States contributed the most publications, also the countries with the most articles per million population were Scotland, Singapore, and Ireland, respectively. The three most used keywords were "noise pollution", "noise" and "traffic noise".

3. This study can be considered to help researchers as it provides summary for current research. It was seen that the USA dominates research on noise pollution, and economically developed countries produce more articles per million population. There is a need for support for global noise pollution studies and for the generation of noise maps.

CONFLICT OF INTERESTS

The author declares no conflict of interest.

ETHICAL APPROVAL

The study conducted a bibliometric analysis of existing published article studies. This study did not require ethics committee approval.

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