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Article

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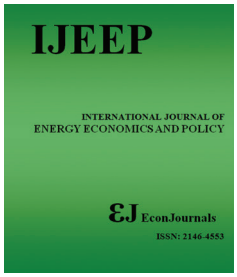

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Sustainable Projects Based on the Intersection of Clean Energy with the Health Sector: A Bibliometric Review

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ABSTRACT

The objective of this work was to develop a bibliometric analysis of academic production related to sustainable projects based on clean, green and renewable alternative energies and their interaction with the health sector and health management on a global scale. To do this, a documentary research process based on bibliometric tools was proposed. The research is limited to the period between 2003 and 2023, executing the following search equation: (TITLE-ABS-KEY (“clean energy”) OR TITLE-ABS-KEY (“alternative energy”) OR TITLE-ABS -KEY (“solar energy”) OR TITLE-ABS-KEY (“green energy”) OR TITLE-ABS-KEY (“renewable energy”) AND TITLE-ABS-KEY (“health sector”) OR TITLE-ABS-KEY (“healthcare sector”) OR TITLE-ABS-KEY (“public health service”) OR TITLE-ABS-KEY (“health management”)). The years with the highest production were 2020 (21), 2021 (23), 2022 (30) and 2023 (34), while the countries that have contributed the most to the topic are China (111), the USA (97) and the United Kingdom (71), which together contributed 57.76% of all publications. Of 145 sources found that published on the topic, the 18 main sources concentrate 48% of the publications. The three most cited articles were Emadian et al., 2017, Waste Manage, Watts et al., 2018, Lancet and Fuller et al., 2022, Lancet Planet Health, with a total of 1567 citations. Among the most relevant institutions in relation to the topic of study, University College London stands out above all with 19 publications, followed by Tsinghua University (9) and Wuhan University (8); between the three institutions they account for 20.57% of the publications found. This analysis provided critical insights for academics and professionals and underscored the relevance and dynamism of this research area in addressing clean energies and sustainable projects related with health management and health sector worldwide.

Keywords: Sustainability, Alternative Energies, Renewable Energies, Health Sector, Health Management
JEL Classifications: K32, I15, Q42

1. INTRODUCTION

Globally, there is a highly dynamic context regarding the incorporation of renewable energies in the different economic and industrial sectors, this is due to the growing environmental needs that society presents in the last decades, where the industrialized development of large cities has generated a profound impact on the ecosystem worldwide, with profoundly serious consequences such as temperature extremes and heatwaves, hydrological change, floods and droughts and proxies for impacts on crop yields (Arnell et al., 2019). In this order or ideas, the great threat of changing global climate has seriously focused the attention of specialist, as these changes are reporting negative impact on different issues such as: global crop production which compromises food

security around the world (Raza et al., 2019), a latent growth in the demand of cooling, while there is the expectancy for an important diminution in heating demand, which are contrasting with the slight decreases in hydropower and thermal energy capacity (Yalew et al., 2020), just to mention a few of the most relevant problematics humanity faces today.

Therefore, a vital relevance has been generated towards establishing a balance between the economic activities of nations and the commitment to reducing the environmental impact generated by them and their increasing development, so climate change reduction and the adaptation methods worldwide in the different sectors comes into action (Garcia-Samper et al., 2022). Following the findings of Abbass et al., (2022), it is needed from the nations' administrations to get involve for their countries' long-term development with high rigor use of resources and the implementation of regulations to update current climate policies. In this sense, reducing the impacts of climate change is gaining the biggest importance, and that is why this worldwide threat requires global obligation to address its alarming implications to ensure global sustenance.

Following the aforementioned, the most viable solution to reduce these global threat is by developing power generation systems based on the exploitation of the renewable energy resources; these systems consists in transforming natural energetic fonts into useable energy, like solar radiation, wind current, and biomass, where the most important characteristic is that these resources will not reduce their availability (Kothari et al., 2021). Despite important determinations from all sectors to decrease fossil fuels' dependence with the promotion of alternative energy, these fossil fuels represent the greater contribution to global electricity production with 73.5% by 2017. On the other hand, renewable energy's contribution reached only 26.5% (Qazi et al., 2019). This context is produced mostly for the almost absent public awareness as the biggest obstacle to the reception of renewable energy technologies, which could collaborate managing this global energy crisis by integrating these energy's sources to the power generation systems (Østergaard et al., 2020).

The main goal for the growing development in investing and exploiting these energies is to reach the preservation of nature and sustainability. Renewable energy sources are not only the least predominant resource, but also infer some disadvantages for electrical production processes, like the dependency on weather conditions, and the capacity of electrical production (Maradin, 2021). So in this context, it is important to highlight that some studies had exposed the relevance to continue with the expansion in this topic in order to make it visible (Levenda et al., 2021).

In the last years, companies in different sectors have adopted environmentally friendly methodologies, where it is imperative the identification of environmental practices that increase sustainability (Ramirez et al., 2023). These organizations should establish policies that meet guidelines which will have influence to the implementation of green human resource management processes for maximizing sustainable performance (Mousa and Othman, 2020). Within the context of the healthcare sector, which pollutes by itself with a great responsibility of the carbon footprint. So globally healthcare institutions have recognized their impact and are working towards changing their energetic choices, looking forward to 100% renewable electricity for their facilities. But it is an uncertain process on how fast this kind of institution could accomplish this goal (Burch et al., 2021).

2. METHODOLOGY

This study is based on bibliometric techniques, an area of scientific observation aimed at research in the form of scientific products such as scientific articles, book chapters, and other written typologies (Ramírez-Duran et al., 2023). These bibliometric techniques are based on the search, through a search equation of specialized terms, of the most outstanding and relevant scientific contributions within one or several databases (Agbo et al., 2021).

On the development of this research, a systematic literature search was conducted in the Scopus database in January 2024 with the keywords "clean energy," "alternative energy", "solar energy", "green energy", "renewable energy", "health sector", "healthcare sector", "public health service" and "health management." The Table 1 below shows the standardization of the keywords.

Based on these variables and descriptors, a search is proposed in the Scopus database; which is selected for high coverage of areas of knowledge and its support in the indexing of high-impact sources. The resulting search equation is the following, taking into consideration the observation period from 2003 to 2023: (TITLE-ABS-KEY ("clean energy") OR TITLE-ABS-KEY ("alternative energy") OR TITLE-ABS -KEY ("solar energy") OR TITLE-ABS-KEY ("green energy") OR TITLE-ABS-KEY ("renewable energy") AND TITLE-ABS-KEY ("health sector") OR TITLE-ABS-KEY ("healthcare sector") OR TITLE-ABS-KEY ("public health service") OR TITLE-ABS-KEY ("health management")).

In this way, with the findings obtained, information processing is carried out by applying validated tools for bibliometric studies, such as the bibliometrix package of the R software for the general analysis of the data and application of bibliometric laws; in addition to the Vos Viewer software for mapping the existing networks between the documents studied from various indicators.

The results obtained from the search equation were refined by applying, as an inclusion criterion, that only documents published from 2003 to 2023 were included, 175 documents were obtained. The Excel program, the Bibliometrix module of the R software and the VOSviewer software were used to analyze the data. The results

Table 1: Keyword standardization

Keywords	Descriptors
Clean energy	*Clean energy *Alternative energy *Solar energy *Green energy *Renewable energy
Health sector	*Health sector *Healthcare sector *Public health service

were exported from WOS in bibtex format. General information about the published articles is presented in Table 2.

Table 2 shows the main information of the articles consulted in a time interval from 2003 to 2023; In total, 175 documents were analyzed, with an average of citations per document of 23.36 and a total of 719 authors and 145 journals.

3. RESULTS AND DISCUSSION

Initially, an analysis of bibliometric productivity was carried out, then different bibliometric indicators were analyzed and finally the analysis of relationships and co-occurrences was carried out.

3.1. Laws of Bibliometric Productivity

Lotka's law shows the quantitative relationship of the contribution of authors who carry out studies in a specific field to the literature and is an indicator of scientific productivity, the number of authors who have made n contributions was approximately $1/n^2$ times the number from authors who have made a single contribution (Lotka, 1926). It is deciding the number of authors specialized in a specific research topic is limited.

In Figure 2 and Table 3, Lotka's law is observed, the greatest number of authors (683) which is equivalent to 95% are those who have made the least contributions to the field of study with a single article and only 5% (36 authors) have made 2 or more publications. Based on the above, it is inferred that the vast majority of publications are made by researchers who carry out temporary research on the topic of study.

On the other hand, according to Bradford's law it represents the productivity of the magazines; According to this, journals in a specific field are classified based on the number of publications they contain. The journals are divided into three productivity zones with an increasing number of journals and a similar number of articles. Bradford's law was used to calculate the target weight of each journal (Cortés-Tomás et al., 2021).

Table 4 shows that 33.14% of the published articles are concentrated in the top 28 journals and that these belong to zone 1 of Bradford's law, where a relatively small number of journals that are the most productive are concentrated.

Of these, the first 18 sources can be highlighted, as seen in Figure 2, which correspond to 64.29% of the total publications of the journals that make up zone 1 of Bradford: IOP Conference Series: Earth and Environmental Science, Renewable and Sustainable Energy Reviews, Energies, Environmental Science and Pollution Research, International Journal of Environmental Research and Public Health, Renewable Energy, Applied Energy, Australian Health Review, Electronics (Switzerland), Frontiers in Energy Research, IEEE Access, IFAC-Papersonline, International Journal of Hydrogen Energy, Journal of Energy Storage, PLoS One, Sustainability (Switzerland), the Lancet, the Lancet Planetary Health. Together, they account for 48% of the publications found, with the 18 sources mentioned being the only ones with two or more publications in the area studied.

Table 2: Main information of the data obtained from scopus

Main information about data	
Timespan	2003:2023
Sources (Journals, Books, etc.)	145
Documents	175
Annual Growth Rate %	19.28
Document Average Age	4.91
Average citations per doc	22.36
References	6708
Document contents	
Keywords Plus (ID)	1723
Author's Keywords (DE)	519
Authors	
Authors	719
Authors of single-authored docs	12
Authors collaboration	
Single-authored docs	12
Co-Authors per Doc	4.35
International co-authorships %	30.86
Document types	
Article	72
Book	2
Book chapter	7
Conference paper	53
Conference review	10
Editorial	4
Letter	1
Note	3
Retracted	1
Review	22

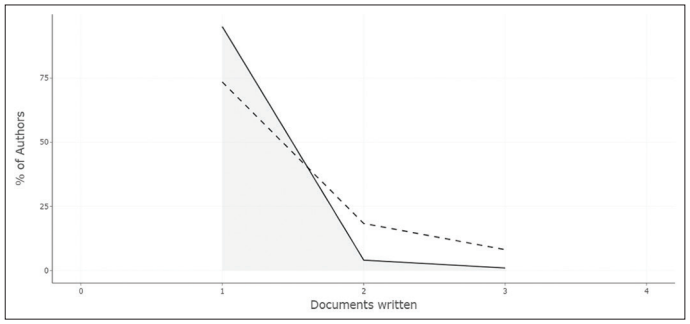
Table 3: Lotka's law

Written documents	N. of Authors	Proportion of authors
1	683	0.95
2	29	0.04
3	7	0.01

Table 4: Bradford's law

Zone	No. Journals	No. Titles	Percentages
Zone 1	28	58	33.14
Zone 2	60	60	34.29
Zone 3	57	57	32.57

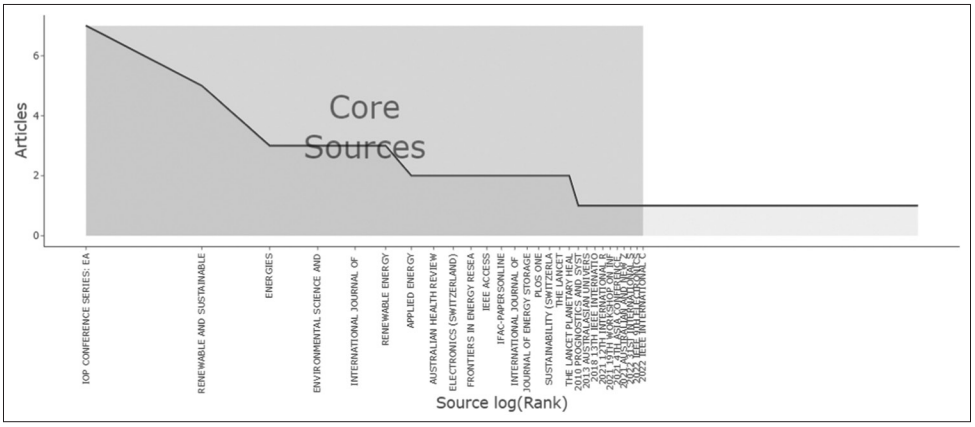
Figure 1: Lotka's Law



Source: Author based on information from Scopus (2024)

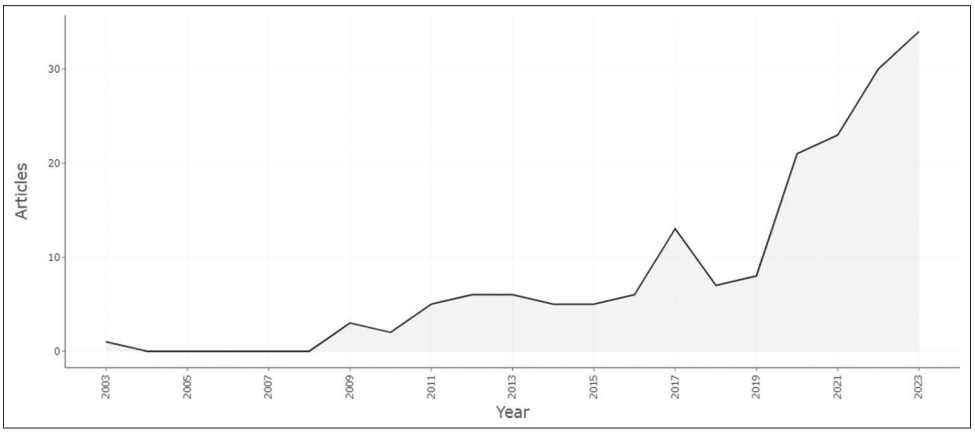
This underscores the significance of these journals as significant research sources in the field, as they concentrate a substantial proportion of publications and can, therefore, provide valuable insights and essential information for researchers and professionals in the field.

Figure 2: Bradford's Law



Source: Author based on information from Scopus (2024)

Figure 3: Annual scientific production



Source: Author based on information from Scopus (2024)

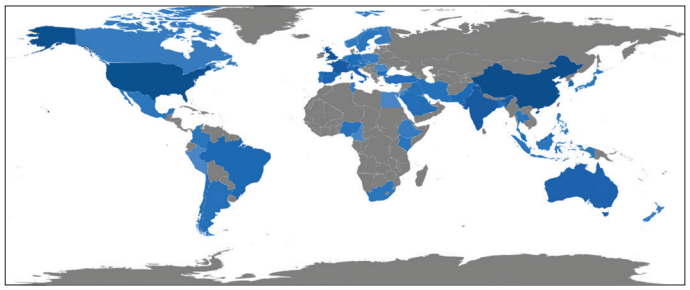
3.2. Bibliometric Indicators

Figure 3 highlights the years 2020 (21), 2021 (23), 2022 (30) and 2023 (34), in which there was a meteoric growth in publications related to the research topic. In these years, 61.71% of all the research carried out was concentrated, which indicates a clear interest in the research topic, and is confirmed by the pronounced growing trend represented in the graph.

To determine which countries have made the most publications on the topic of study, a geographical analysis was carried out, which can be seen in Figure 4; the countries that have contributed to the field of study are represented on the map; the darker the hue, the more contributions it has made. China (111), the USA (97) and the United Kingdom (71) can be highlighted. Between these two countries they contribute 57.76% of all publications in the field of study, followed by France (45), India (45), Australia (28), Italy (27), South Korea (21), Spain (21) and Netherlands (17).

On the other hand, an analysis of the most relevant sources on the research topic was carried out; Figure 5 shows that the 2 journals that publish the most on the topic are IOP Conference Series: Earth and Environmental Science (7) and Renewable and Sustainable Energy Reviews (5). Both sources alone account for 12% of the literature found, for a total of 145 sources collected by the analysis.

Figure 4: Scientific production by country



Source: Author based on information from Scopus (2024)

As for the most relevant authors, the production per author is low compared to the number of articles published from 2003 to 2023. As can be seen in Figure 6, only 7 of 719 authors, that is, 0.97% of the authors found, have published 3 articles related to the topic studied: Compare M, Flynn D, Hissel D, Saidi L, Wang X, Zhang H and Zio E. The rest of the authors found have published only 1 or 2 related articles.

Next, Table 5 shows the 25 publications that have the most citations. Of these, the three most representative are: Emadian et al., 2017, Waste Manage (629); Watts et al., 2018, Lancet (533); and Fuller et al., 2022, Lancet Planet Health (405). Between the

Figure 5: Most relevant sources

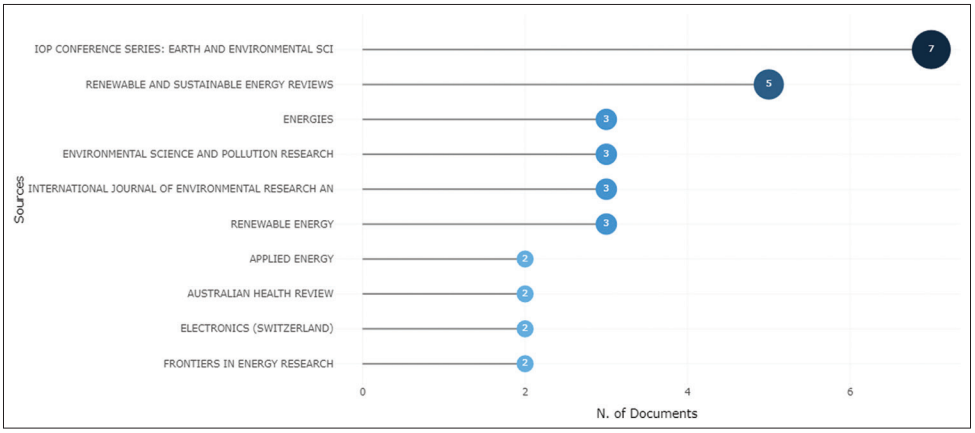


Figure 6: Most relevant authors

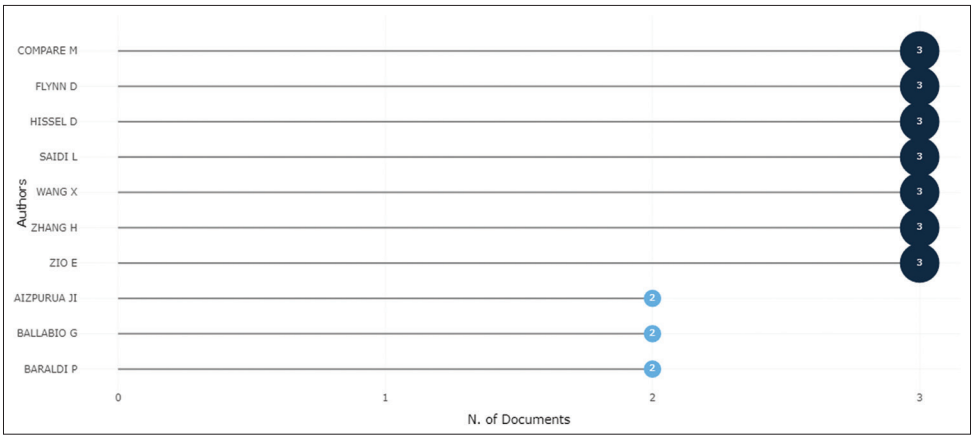


Table 5: Most cited articles

Articles	DOI	Total of Citations
Emadian et al., 2017, Waste Manage	10.1016/j.wasman. 2016.10.006	629
Watts et al., 2018, Lancet	10.1016/S0140-6736 (18) 32594-7	533
Fuller et al., 2022, Lancet Planet Health	10.1016/S2542-5196 (22) 00090-0	405
Meng and Li, 2019, Renewable Sustainable Energy Rev	10.1016/j.rser. 2019.109405	197
Jouin et al., 2013, Int J Hydrogen Energy	10.1016/j.ijhydene. 2013.09.051	176
Kandukuri et al., 2016, Renewable Sustainable Energy Rev	10.1016/j.rser. 2015.08.061	171
Rocchetta et al., 2019, Appl Energy	10.1016/j.apenergy. 2019.03.027	132
Tao et al., 2017, Renewable Sustainable Energy Rev	10.1016/j.rser. 2017.05.127	76
Kasana et al., 2017, Environ Chem Lett	10.1007/s10311-017-0615-5	72
Chen et al., 2017, Int J Hydrogen Energy	10.1016/j.ijhydene. 2017.05.241	65
Shang et al., 2022, Renew Energy	10.1016/j.renene. 2022.04.013	60
Omariba et al., 2018, Electronics (Switzerland)	10.3390/electronics7050072	60
Khan et al., 2021, IEEE Access	10.1109/ACCESS.2020.3047732	53
Correa-Jullian et al., 2020, Renew Energy	10.1016/j.renene. 2019.07.100	53
Costello et al., 2011, Philos Trans R Soc A Math Phys Eng Sci	10.1098/rsta. 2011.0007	53
Frumkin et al., 2009, Public Health Rep	10.1177/003335490912400103	49
Heffron et al., 2021, Renewable Sustainable Energy Rev	10.1016/j.rser. 2021.110743	47
Riley and Johnson, 2012, Conf Rec IEEE Photovoltaic Spec Conf	10.1109/PVSC.2012.6317887	47
Javed et al., 2015, Proc IEEE Int Conf Ind Technol	10.1109/ICIT.2015.7125235	45
Hissel and Pera 2016, Annu Rev Control	10.1016/j.arcontrol. 2016.09.005	44
Chan and Mo 2017, Energy Procedia	10.1016/j.egypro. 2017.03.148	43
Weisz et al., 2020, Resour Conserv Recycl	10.1016/j.resconrec. 2020.104862	40
Zinsstag et al., 2012, Onderstepoort J Vet Res	10.4102/ojvr.v79i2.492	37
Pinciroli et al., 2022, Renew Energy	10.1016/j.renene. 2021.11.052	28
Murthy et al., 2021, J Asian Financ Econ Bus	10.13106/jafeb. 2021.vol8.no2.0801	27

three publications, they concentrate 1567 citations, no less than 49.87% of the citations among all the publications found.

Subsequently, the most relevant affiliations found were analyzed, discriminated by country and number of articles published, as

Figure 7: Co-occurrence of keywords using VOSviewer software based on information from Scopus

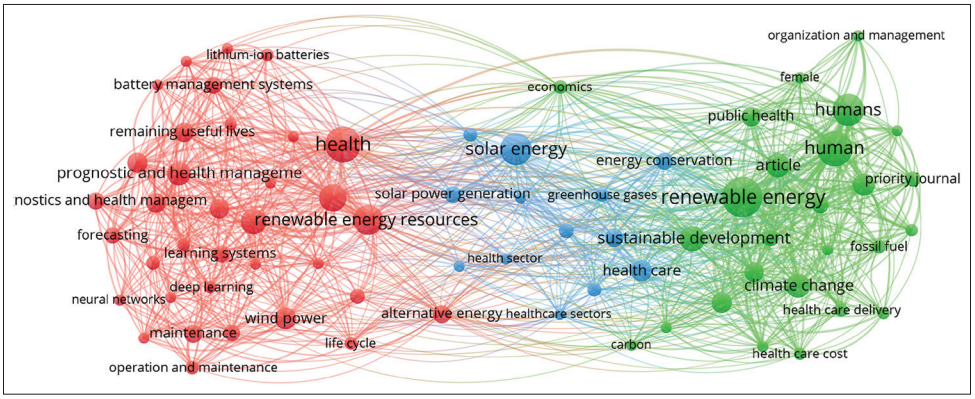


Table 6: Ten most relevant affiliations

Affiliation	Articles
University College London	19
Tsinghua University	9
Wuhan University	8
Zhengzhou University of Light Industry	7
Beihang University	6
California Department of Public Health	6
Global Alliance on Health and Pollution	6
Kyungpook National University	6
London School Of hygiene and Tropical Medicine	6
Northwestern Polytechnical University	6

shown in Table 6. It shows the ten institutions that have published the most documents regarding sustainable projects based on clean energy and their interaction with the health sector; Of these, University College London (n = 19) stands out above the rest, followed by Tsinghua University (n = 9), Wuhan University (n = 8) and Zhengzhou University of Light Industry (n = 7). These three institutions alone account for a total of 20.57% of the publications found.

Finally, the analysis of relationships and co-occurrences was done using the VOS viewer software, taking as a parameter that the author has at least two articles and two citations. For this research, a keyword co-occurrence analysis was carried out, where a total of 3 clusters were identified, highlighting the words: health, renewable energy resources, solar energy, health care, sustainable development, renewable energy, human and humans. All this is shown in detail in Figure 7.

4. CONCLUSIONS

The bibliometric analysis developed was delimited in a time interval from 2003 to 2023; In total, 175 publications were analyzed, with an average of citations per document of 23.36 and a total of 719 authors and 145 sources. From this bibliometric analysis, based on the information obtained from WOS on sustainable projects based on clean, green and renewable alternative energies and their interaction with the health sector and health management on a global scale, it can be said that:

The highest peaks of publications occur in the years 2020 (21), 2021 (23), 2022 (30) and 2023 (34), in which an exponential growth of publications related to the research topic is seen. In these years, 61.71% of all the publications found are concentrated. A surprising revelation from this study was the profound scientific production emanating from China, the USA and the UK, which together contributed 57.76% of all publications, underscoring the global importance of the integration of sustainable projects based on clean energies with the health sector. Notable contributions were also noted from France, India, Australia, Italy, South Korea, Spain and Netherlands, highlighting the scope and international collaboration in this field.

Among all the sources found, mainly two of them stood out as epicenters of academic discourse, these being IOP Conference Series: Earth and Environmental Science and Renewable and Sustainable Energy Reviews. The fact that only two magazines account for 12% of the publications related to the intersection between the health sector and renewable energy projects, for a total of 145 sources collected by the analysis, are a reminder of both the selfless interest of both sources for generating knowledge on the subject as well as the need to delve into a intersection of thematic lines that, as has been highlighted in the production each year, arouses more and more interest.

In relation to the most prominent researchers, a low production by the authors is observed compared to the number of articles published from 2003 to 2023. According to the results, only 7 of the 719 identified authors, which is equivalent to the 0.97% of the total, have contributed to the publication of 3 articles linked to the topic analyzed. These authors are Compare M, Flynn D, Hissel D, Saidi L, Wang X, Zhang H, and Zio E. On the other hand, the remaining authors have published only 1 or 2 articles related to this specific topic.

The three most referenced articles have been identified as Emadian et al., 2017, in the journal Waste Management (629 citations); Watts et al., 2018, in The Lancet (533 citations); and Fuller et al., 2022, in Lancet Planetary Health (405 citations). These three publications concentrate a total of 1567 citations, which represents almost half, specifically 49.87%, of all the citations collected among all the publications examined. Then, the ten institutions with the highest production of documents related to sustainable projects based on clean energy and their impact on public health were identified. University College London stands out in first

place, followed by Tsinghua University, Wuhan University and Zhengzhou University of Light Industry. These three institutions together cover a total of 20.57% of the publications analyzed.

The bibliometric research carried out highlights the growing relevance of the health sector in the development of projects oriented towards clean, green and renewable energies. This study reveals a widespread interest at a global level, with the key participation of specific countries and specialized journals. Likewise, it highlights the outstanding role of a select group of researchers in this area. These findings not only provide valuable insights for the academic and professional community, but also underline the importance and dynamism of this field of research in addressing critical challenges related to energy, public health and sustainability on a global scale. In summary, this analysis highlights the continued relevance and potential for significant impact that this interdisciplinary field has on the global sustainable development agenda.

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