BIBLIOMETRIC ANALYSIS OF PUBLICATIONS ON "HAZARDS AND HEALTH EFFECTS ASSOCIATED WITH WELDING" FROM 2010 – 2023

Abstract

An overview of the hazards and health effects associated with exposure to welding fumes is provided in this paper through adaptations from various sources. The growing concerns around welding and its attendant health effects are valid as welding fumes are inherently hazardous and are composed of particulate matter from condensed metals and obnoxious gases such as Ozone which have been implicated in the aetiology and pathophysiology of many diseases including cancer. Information currently available from various published study works is described in the review. In accordance with the bibliometric analysis, "The United States" ranks as the most prolific contributor, with a large collection of works from active organizations such as the National Institute of Occupational Safety and Health (NIOSH). Additionally, author cooperation has increased recently and is more common in groups. Three hot themes in welding-related hazards and health effects—"human," "age," and "occupational exposure"—were identified across all keyword analyses. Furthermore, oxidative stress, occupational diseases, risk management, cohort studies, and air pollutants in welding were identified as new themes by the keywords analysis. To the extent that we are aware, this study is the first explicit bibliometric approach to visualize the research field of health and hazard impacts related to welding. It is helpful for locating hotspots in active research now and for speculating on prospective future research areas.

Keywords: Bibliometric analysis; hazards and health effects; welding

1. Introduction

More than 80 distinct welding techniques and related procedures exist [1]. Some of the most popular types of welding are arc welding, which includes "stick" or shielded metal arc welding (SMAW), the gas-shielded methods of metal inert gas (MIG) and tungsten inert gas (TIG), plasma arc welding (PAW), and submerged arc welding [1,2]. The use of oxygen-acetylene gas, electrical current, lasers, electron rays, friction, acoustic sound, chemical reactions, heat from fuel gas, and robots are other welding techniques. Around the globe, hundreds of millions of people work in hazardous or unhealthful conditions [3]. Over two million individuals per year are thought to pass away from occupational diseases and injuries worldwide [4]. In actuality, more people die from occupational diseases than from industrial accidents [5].

Despite the fact that welding procedures are fraught with a variety of risks, only 2% of Occupational Safety and Health Association (OSHA) general industry citations specifically address this issue [6]. Earlier studies had emphasized the difficulties that developing nations faced when implementing risk evaluation and control methods in the welding sector. As it turns out, many of the substances present in brazing vapour, such as chromium, nickel, arsenic, asbestos, manganese, silica, beryllium, nitrogen oxides, cadmium, phosgene, acrolein, fluorine compounds, cobalt, zinc, copper (Cu), ozone (O_3), selenium, carbon monoxide (CO), and lead (Pb), can be very poisonous.

It has been reported that welding is a major and highly skilled process that emits fumes that are extremely hazardous to one's health. Epidemiologic studies demonstrate that there are various health effects threatening humans during the welding process, and some of these potential hazards include: gases (acetylene, CO, NO, ozone, phosgene, etc.), physical hazards (electricity, hot environment, ultra violet, noise, visible light, etc.) and metal oxide fumes (Cd, Cr, CO, Cu, Fe, Pb, Mn, Ni, Zn, etc.) which expose the workers to most destructive and dangerous welding byproducts [7-9]. Additionally, coatings may emit vapours and gases, and the use of some new coatings, such as boron nitride tiny particles, may have negative health consequences despite having no known impacts on toughness or resilience to wear [10]. Because the regulatory standard for compliance only takes into account one constituent, the risk evaluations for welding fume exposure currently tend to concentrate on a single welding fume constituent. Welders are actually subjected to a variety of welding fume components at once in reality.

It is challenging to compile a summary of the adverse impacts of welding exposure on one's health because the fumes contain a wide variety of hazardous components, depending on the many variables such as the composition of the base metal, the methodology of welding employed, the consumables utilized, the skill set of the welder working and work practices among other factors [11-13]. The kidneys, lungs, heart, and central nervous system are just a few of the bodily parts that welding smoke's individual constituents can harm. While all welders are at risk, smokers may be more likely than non-smokers to experience health problems.

Based to a random experiment carried out by Wong and coworkers on 2034 individuals, greater people who smoke who work in the welding and foundry sector for a longer time frame of time have a higher risk of developing lung cancer [14]. Out of 53,454 usual smokers, 2,034 lung cancer incidents were incident lung cancer cases. Corresponding to this, in a cohort study by Siew et al. [15] all Finnish males in the working age category who took part in a census in 1970 were tracked by the Finnish cancer registry for cases of lung cancer (1,971 – 1,995). This study established the link between prolonged exposure to iron and welding fumes and an increased risk of developing lung cancer, particularly squamous cell carcinoma [15]. The formation of DNA-protein cross-links by welding fumes containing metals like Cd and Ni may have an effect on the onset and spread of cancer. Li et al. [16] selected welders from a car manufacturer for the study, while the control subjects came from a nearby food factory. Serum amounts of iron and manganese were 4.3 and 1.9 times higher in welders than in controls, respectively. Welders had 2.5 times the amount of "Lead (Pb)" in their blood compared to controls, while their serum zinc levels fell by 1.2 times. The findings of linear regression revealed no relationship across the age of the welder and the blood levels of five metals. According to their research, welding fumes can cause oxidative stress and disrupt the balance of trace elements in the body's circulation.

The impact of pulmonary exposure to metal fumes fine (2.5 m) particulate matter ($PM_{2.5}$) on sleep disorders is receiving more and more focus [17]. There is a link between welding fumes and sleep disorders, according to earlier research. For instance, a case study revealed that employees exposed to welding fumes containing Mn displayed signs of olfactory, extrapyramidal, sleep, and mood disturbances [18]. According to Chuang et al. [19], welders spend more time awake than office employees do.

The health risks associated with working environments are, however, receiving more attention as industrialization advances, and the manufacturing sector is making greater efforts to produce products that are ecologically friendly and promote sustainable development. The risks and health effects connected with welding as an industrial field had to be taken into account when evaluating workplace risks. It is also challenging to gain deeper insights into publishing patterns and interest in the research issue for the aim of detecting novel welding-related dangers and health consequences because no such systematic analysis has been performed. In order to assess the knowledge structure, hot themes, and trend directions of this area, a thorough bibliometric and visual analysis was performed using VOSviewer via articles from the dimensions database.

2. Methodology

This research adopted the systematic literature review method, specifically, the bibliometric method which is very efficient at assessing the potential knowledge structure contained in academic literature and combining visible results for additional investigation in this area [20].

The sample of the study consists of 2,113 documents published in journals that were prepared with the focus of hazards and health effects associated with welding scanned in the "Dimensions" (Available from:https://app.dimensions.ai/discover/publication), database between 2010 and 2022. To reach the sample, the database was scanned using the keywords "hazards, health effects, associated with welding".A contemporary research system with democratized data and a broader lens through which we can view research outputs is what was envisioned by Dimensions, which was created by Digital Science [21]. With the requirement that each publication have a unique DOI, another indexation technique is the Dimensions catalogue[22].

The data wasexported on Feb 27th, 2023 using the criteria: "welding-related hazards and health consequences" in full data; "health effects associated with welding"; "health effect of welding"; "hazards associated with welding". Following the research done since this date and its focus points over time is one of the study's main goals. The research included more sources that were in article format and written in English.

The present research aims to assess the publications of the health risks and effects of welding to the development of subsequent studies concurrent with the particular method.

The VOSviewer software was utilized to perform a bibliometric assessment in support of a systematic literature review and to gather complete data on prior research on the topic. Nevertheless, the bibliometric analysis was planned and presented in accordance with four fundamental standards: textual information, keyword density, sample size, and writers who were the forerunners in the field. VOSviewer is a program for creating visual maps from prevalent words in multiple texts [23]. With the help of this program, the relationships between the outcomes of the text evaluation are displayed in both graphic and distance-based maps, as well as the strength of these relationships.

3. Results

The data in this section on "hazards and health effects associated with welding" publications have been qualitatively analysed in-depth. In section 3.1 we examined the pattern in publication volume over the past few decades, and Section 3.2 analysed the featured authors. In addition, the top 20 authors were elaborated (section 3.3), and the results of top 25 leading scientific journals (section 3.4) and subject areas in section 3.5.

3.1 Publication Trend

Figure 1 displays the yearly distribution of publications from 2010 to 2023. Although there have been ups and downs in the number of publications on the hazards and health impacts of welding, overall, there has been an increase. But in 2014, the directory showed a sharp increase in the quantity of publications (Figure 1). With fewer than 40 articles released prior to 2013, the body of literature was small and growing very slowly. However, the quantity of studies started to progressively rise from 2013 to 2014. After 2017, a noticeable rise was seen, and a major decline happened from 2022 to 2023. Additionally, it was noticed that 37 articles were published on average, and in the most recent ten years, there were even 90. Although there haven't been many studies done on the subject, research on the health risks and impacts of welding (HHEAW) has advanced quickly.

Figure 1. The publication trends from 2010 – 2023

On the distribution of publication type, it was observed that Book chapters had the highest (906) followed by Journal Articles (668), then Edited Books (427), Monograph was (248), Proceeding (26) and the smallest was the Pre-print which showed (22), 1% of the total (Figure 2).

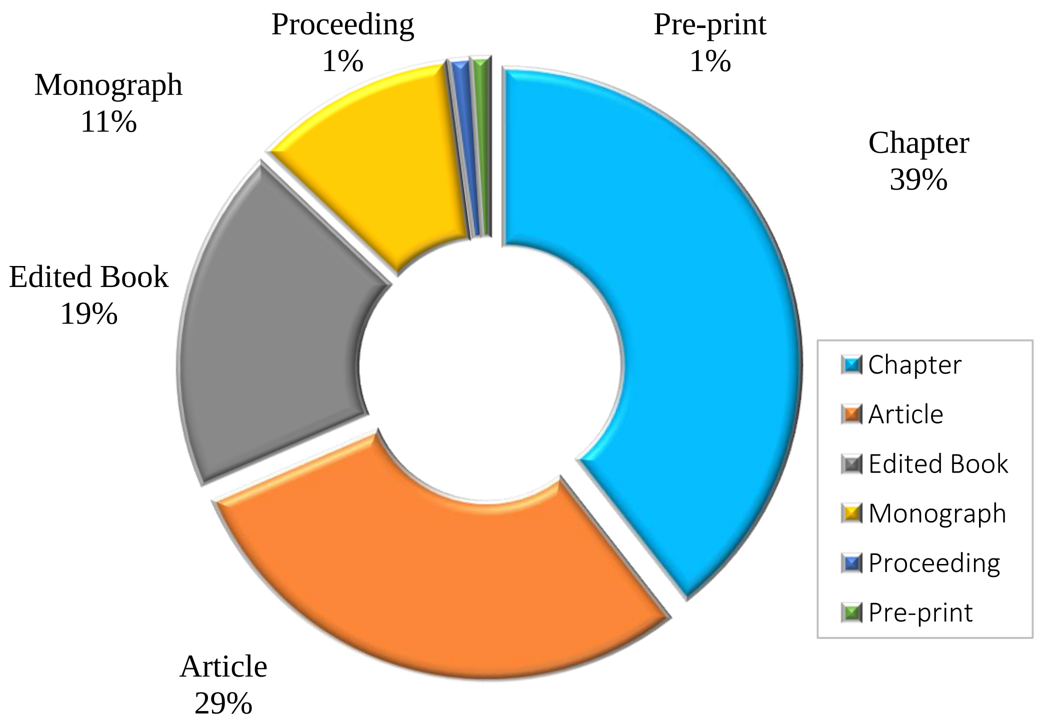

Figure 2. The distribution of publication types

3.2 Featured Authors

Co-authorship based on authors who have written papers on the risks and impacts of welding on the body. A single author may only have 5 documents total; of the 12036 writers, 219 have reached the limit. For each of the 219 authors, the overall strength of the co-authorship link with other authors was computed. Table 1 lists the top 20 writers with the highest total link strength, with dark green representing the strongest links. With 1331 citations and 2327 link strength, "*Antonini, James M*." was found to have the most publications, followed by "Erdely, Aaron" with 29 publications and 474 citations. (Table 1). Additionally, VOSviewer was employed to perform the co-citation analysis measured in cited sources. A cited reference must receive at least 20 cites, and only 155 of the 84539 cited references do so. The overall strength of the co-citation connections with other cited references was determined for each 155 cited references.

Figure 3 displays the referenced sources with the strongest overall links. The majority of authors became more involved after 2010, as shown in Figure 3. As the field's number of writers increased over time, so did the frequency of their interactions with one another. In addition, a number of writers organized themselves into small groups based on their collaboration and published authorship. In Figure 3, cluster 1 has 27 items, cluster 2 (21 items), cluster 3 (20), cluster 4(12), cluster 5(11), cluster 6(10), cluster 7(7), cluster 8(6) and cluster 9(5 items). In a total of 9 clusters, "*Antonini, James M.*". has the highest citation among all author who have published works on this topic.

Table 1. The top 20 authors with the greatest quantity of publications

Author	NP	NC	TLS
Antonini, James M.	42	1331	2327
Erdely, Aaron	29	474	1306
Brüning, Thomas	27	640	1440
Aschner, Michael	24	1201	635
Christiani, David C.	23	749	365
Pesch, Beate	22	544	1380
Weiss, Tobias	22	552	1353
Zeidler-Erdely, Patti C.	22	384	1198
Roberts, Jenny R.	21	975	1370
Checkoway, Harvey	17	485	704
Kendzia, Benjamin	16	489	857
Thomassen, Yngvar	16	190	448
Racette, Brad A.	15	511	579
Broberg, Karin	14	194	354
Demokritou, Philip	14	484	265
Lehnert, Martin	14	380	989

Mckinney, Walter	14	118	617
Kodali, Vamsi	13	146	431
Van Gelder, Rainer	13	360	972

NP = Number of publications, NC = Number of citations, TLS = Total publication link strength

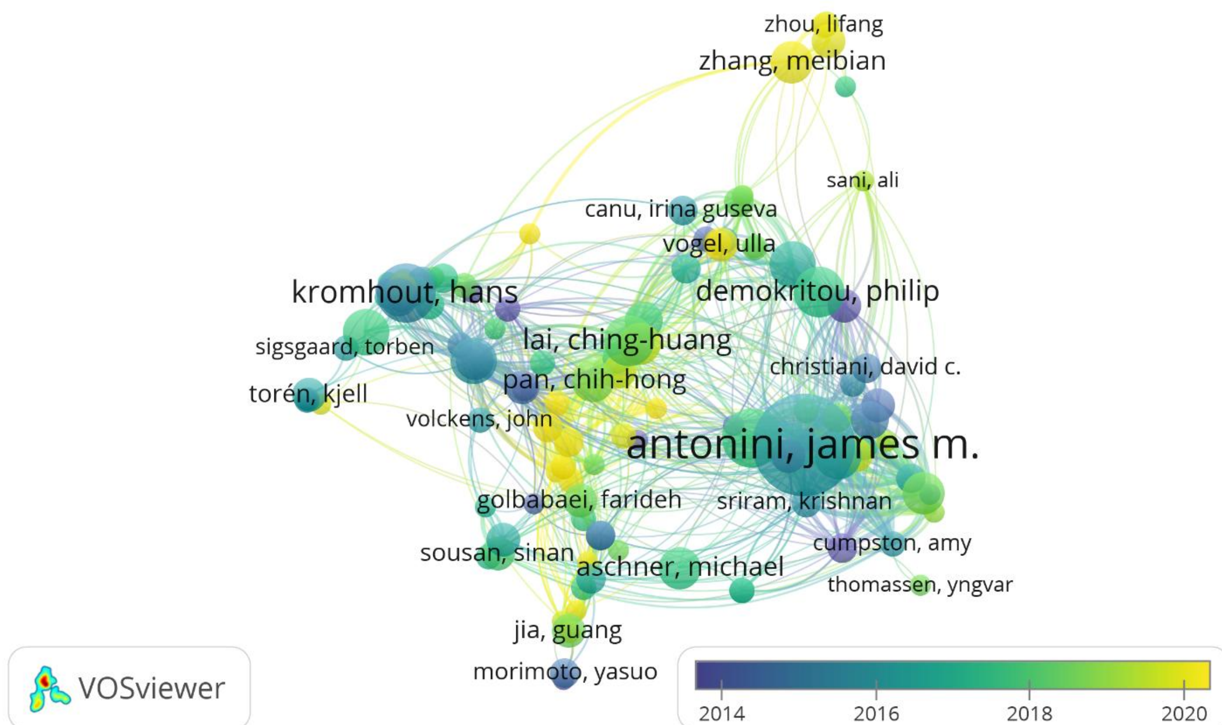

Figure 3. The networked illustration of citation of authors

All 2,792 of the published papers' bibliographic couplings pass the test. The overall strength of bibliographic coupling links with other documents was calculated for each of the 2,792 documents. Figure 4 displays the papers with the most citations, “Tchounwou(2012)” was found to have the greatest number of citations on publications, followed by Zhang (2012). In Figure 5, the co-occurrence of all keywords is displayed, it shows that the terms “humans”, “adults”, “females” and “age” are the most frequently used keywords. These could have occurred as a result of experiment or questionnaire investigations which is a type of study in literature. However, these terms are related to hazard and health effects associted with welding but they are not core keywords. The core keywords that preceds is “occupational exposure”.

Figure 4. The overlaying graphics of citation of documents

Figure 5. The network representation of co-occurrence of all keywords

3.3 Scientific Journals Featured

Only 95 out of 709 sources that were combined bibliographically for journals satisfy the required minimum of 5 documents per source. The overall link strength of the bibliographic coupling links with other sources was determined for each 95 sources. Table 2 lists the sites with the highest overall link strength, and Figure 6 displays the visualization. It was found that journals from environmental and occupational studies are read the most frequently. As shown on the legend in Figure 6, "International journal of environmental research and public health" had the highest degree of occurrence among all journals, spanning the years 2014 to 2020. With a total link strength of 14757, "neurotoxicology" in Table 2 displayed the strongest communication connection among all journals. However, the "International journal of environmental research and public health," which had the most articles (126) had a weaker interaction than neurotoxicology. Similarly, the present review showed that “National Institute for Occupational Safety & Health (NIOSH)” is the most active organization which contains the highest number of publications (Figure 7). This organization is found in the United States of America. Furthermore, the co-citation of journals is presented in Figure 8. It showed that “journal of health perspective and journal of occupational environmental highest level of co-citations. Therefore, these journals are seen as the most impactful sources of the present topic in research terrain.

Figure 6. The overlaying visuals of featured journals on “hazard and health effects of welding publications”

Figure 7. A network presentation of bibliography of organizations

Figure 8. Network illustration of co-citation of journals

Table 2. The top 25 leading journals with the most publications

Journals	NP	NC	TLS
International journal of environmental research and public health	126	1512	10077
Annals of work exposures and health	66	1123	10423
Journal of occupational and environmental hygiene	56	974	9204
Environmental science and pollution research	53	456	4591
Neurotoxicology	53	1638	14757
Occupational and environmental medicine	52	1187	5650
Materials	46	414	179
International archives of occupational and environmental health	44	592	7810
Journal of occupational and environmental medicine	42	468	4509
American journal of industrial medicine	41	634	3597
The science of the total environment	40	756	3023
Scientific reports	37	362	3581
Environmental research	35	584	3841
Chemosphere	29	468	1781
Toxicology and industrial health	29	177	3699
Plos one	28	369	4666
Journal of hazardous materials	27	480	2235
Frontiers in public health	25	97	1906
Inhalation toxicology	25	517	6303
Environment international	23	257	1937
International journal of occupational safety and ergonomics	22	292	937
Sensors	21	275	490
Ecotoxicology and environmental safety	20	184	2542

Nanomaterials	20	245	1506
Nanotoxicology	20	717	4551

3.4 Participating Countries

The participating countries in “hazards and health effect associated with welding publications”. Out of 98 countries, 58 have the required minimum of 5 papers each, according to a bibliographic coupling of nations. The VOSviewer was used to evaluate the total relationship strength of each of the 58 countries' bibliographic coupling with other nations. Table 3 and Figure 8 list the nations with the strongest overall linkages. Figure 9 shows that "United States," "China," "United Kingdom," and "Italy" are the top four countries in terms of overall link strength.

Figure 9. The network illustration of participating countries based on citation

Table 3. The top 25 leading countries that participated in the publication

Country	NP	NC	TLS	%TP
United States	785	18914	169843	25.81
China	303	3972	50379	9.96
United Kingdom	160	3192	48577	5.26
Germany	144	3302	53037	4.74
Italy	135	2222	41738	4.44
India	127	1812	19923	4.18
France	126	3075	40801	4.14
Canada	125	2491	42026	4.11
Sweden	107	1673	42779	3.52
South Korea	96	1649	21156	3.16
Australia	84	1224	19539	2.76
Spain	80	2091	28873	2.63
Denmark	75	1661	27962	2.47
Iran	75	540	13012	2.47
Netherlands	74	1286	28978	2.43
Norway	73	1129	25876	2.40

Poland	72	836	15332	2.37
Taiwan	63	1301	14864	2.07
Brazil	59	1277	22135	1.94
Finland	52	775	23060	1.71
Japan	52	1024	9721	1.71
Pakistan	46	1257	11690	1.51
Saudi Arabia	45	921	8953	1.48
Switzerland	42	682	15498	1.38
Nigeria	41	305	9261	1.35
Total	3041	58611	805013	100.00

NP = Number of publications, NC = Number of citations, TLS = Total publication link strength, %TP = Percentage of total publications

3.5 Subject Areas

The topic "hazards and health effects of welding" publications was covered by 11 subject (categories) areas in the research terrain. These includes "Engineering had the highest publication of 549 (30%), followed by biomedical and clinical science 213 documents (12%), then "Commerce, Management, Tourism" and "Information & Computing Sciences" with 171 and 160 publications are 9% respectively. The subject areas with small number of publications are: Environmental Sciences 120 (7%), Human Resources & Industries 112 (6%), Chemical Sciences 106 (6%), Health Sciences 104 (6%), Built Environment & Design 98 (5%), Civil Engineering 92 (5%), Manufacturing Engineering 82 (5%) respectively. Therefore, most of the publications on hazards and health effects associated with welding were done in Engineering (Figure 10).

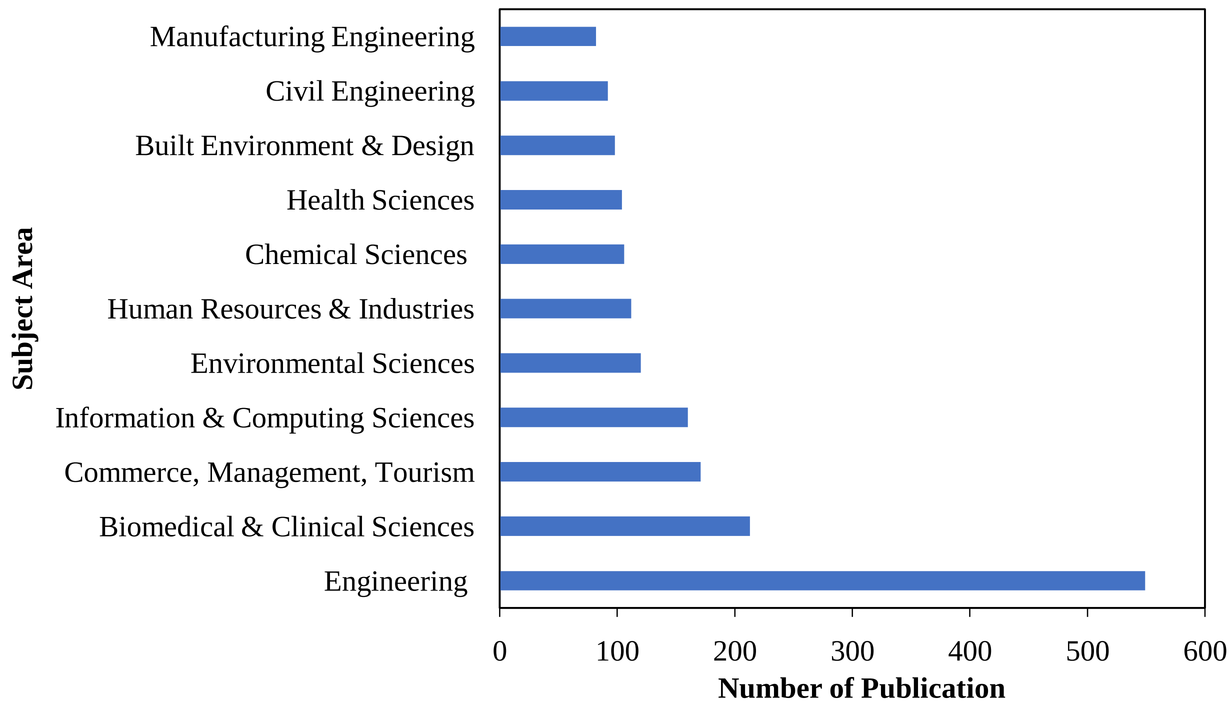

Figure 10. The distribution of subject areas on "hazard and health effects associated with welding" publications

4. Discussion

This study provides a bibliometric examination of publications on the subject of welding hazards and health effects that were indexed by the Dimensions database using the VOSviewer app. Numerous academics have focused on the risks and negative impacts of welding on health. [24-27]. Yet, to date, no works on bibliometric evaluation have summarized and prospected this topic. The main problem with doing this bibliometric analysis traditionally is the reliance on a biased selection of a small number of articles from 2010 to 2023, which may introduce bias and faults in the results [16]. Inadequate coverage of important paths and a lack of significant literature are further drawbacks of the classic main path analysis approach [28]. By fully encompassing all the records from the chosen time period, bibliometric assessment avoids missing important literature, overcomes the limitations of traditional reviews, and allows for quantitative exploration of theoretical frameworks, research priorities, and novel insights of potential scientific fields [29]. In order to provide a more accurate outcome for future research, 2,792 publications from the Dimensions database were examined in this study using bibliometric techniques and the VOSviewer software. This study's bibliometric analysis of the risks and health effects of welding revealed the following facts: (1) the number of published documents in the field has been steadily increasing since 2010, and no year, with the exception of 2022, has shown a burst rise in the number of articles.

From 2013 to 2018, researchers paid more attention to the risks and health impacts of welding, but from 2018 to 2022, their focus significantly decreased. (2) With the most publications, citations, and overall linkage strength, the United States was the primary contributor to this subject. (Table 3). (3) The significance of "humans," "adults," "age," and "female" has been essential in the research field on risks and health effects related to welding papers, combined with the high frequency and centrality of co-occurrence keywords. (4) The analysis of the keyword burst results revealed that human sample populations are being reported more frequently and are a common area of research.

The research topic was illustrated through reading strategies in addition to the analysis and discussion of the study's findings. The majority of the documents on the hazards and health effects of welding are written in applied occupational and environmental hygiene, per the findings of co-reference articles. Although the review showed that significant work has been done on the health effects associated with welding fumes with regard to metal content, a few studies have been conducted on blood and urine sampling of welders to determine health impacts. However, the emerging risks and health effects of welding are still not fully addressed by the available studies.

Conclusion

The welding process poses significant occupational hazards, as evidenced by the findings of this analysis. However, it is worth noting that not all welders possess a comprehensive awareness of the hazards and risks involved. This situation is particularly severe for individuals in proximity to the welding sites who are not actively engaged in welding activities when work is ongoing. In this respect, welding hazards can cause harm to some welders and other individuals simply because they are not aware of them. In this review article, certain safety measures have been advised in order to mitigate welding risks. A novel bibliometric approach was used to highlight the development, hot spots, and trend directions for further research in this study and to more effectively identify the main advancements and new perspectives in this field in order to close the gap in systematic inquiry in the field of hazards and health effects related to welding. The findings showed that, particularly between 2013 and 2014, there was an increase in interest in the study of the risks and health impacts of welding.

It is shown that, excluding the significant considerations devoted to "humans," "age," "adults," "occupational exposure," and "environment," the research hotspots are still within the topic after the investigation of significantly cited references, countries contribution, journals, subject areas, numerical reasoning of keyword frequency, and critical studying of most recent, highly regarded articles. However, the systematic review indicates that it tilts from the effect of welding fume exposure towards emerging health effects and hazards associated with welding. Combining the analysis of keyword bursts with critical reading of significant references allowed for the identification of some potential future research paths. Firstly, the number of studies using specialized research techniques will rise. Furthermore, future research should pay more attention to safety precautions as well as the newly discovered health risks and hazards connected with welding. This research contributes in part to our understanding of the risks and health impacts of welding and lays the groundwork for further investigation in this area.

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