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Review

Occupational Health and Safety in China: A Systematic Analysis of Research Trends and Future Perspectives

Xinglin Chen [1], Fuqiang Yang [1,*], Shuo Cheng [1] and Shuaiqi Yuan [2,*]

[1] College of Environment and Safety Engineering, Fuzhou University, Fuzhou 350116, China
[2] Safety and Security Science Group, Faculty of Technology, Policy and Management, Delft University of Technology, 2628 BX Delft, The Netherlands
* Correspondence: yangfuqiang@fzu.edu.cn (F.Y.); s.yuan-2@tudelft.nl (S.Y.)

Abstract: The frequent occurrence of various occupational accidents has resulted in significant casualties and occupational disease issues, which hinder economic and social development seriously. The promotion and enhancement of occupational health and safety (OHS) require greater efforts to be made to achieve sustainable economic development, particularly in developing countries. With remarkable progress and achievements that have been made in terms of OHS in China, a systematic and thorough review is needed to gain insight into the development process, current status, and research trends regarding OHS in China. Additionally, pathways for future work need to be discussed to boost the OHS development in China in the new era. Therefore, a systematic literature review is performed in this study to investigate the development of OHS in China with the help of a bibliometric analysis. Firstly, a total of 5675 publications related to OHS in China between 1979 and 2022 were collected from the Web of Science Core Collection (WoSCC) and the Chinese Science Citation Database (CSCD) before being refined manually. Then, the temporal distribution and journal sources of the collected publications were analyzed before the collaboration networks of the "productive institutions" and "productive authors" were discussed. Furthermore, the key research topics (e.g., disease prevention, psychological safety, occupational exposure) and dominant research methods (e.g., epidemiological methods, risk modeling) associated with OHS during different periods were identified and discussed based on the keywords and bibliographic analysis. Finally, the current needs and promising pathways for future work were discussed. It is suggested that the prevention and control of conventional and new occupational diseases, the protection of workers' occupational health rights and interests, the development and implementation of advanced technologies for OHS, and the development of more sophisticated and efficient health and safety risk assessment models may be focused on to accelerate the development of OHS in China. This study systematically reviews the development processes, current status, and future prospects regarding OHS in China. The results of this study provide valuable insights for researchers and practitioners who are involved in the Chinese OHS development, and the promising pathways for future works are suggested to boost the OHS development in China.

Keywords: occupational health and safety; China; bibliometric analysis; literature review; research trends

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1. Introduction

With decades of continuous economic development, China became the world's second-largest economy in 2010 by using the shortest time ever to achieve such success [1]. Regarding the development of the economy and social systems, the improvement of the occupational health and safety (OHS) system has also played an important role. Governments at all levels in China have played an important role in guiding and promoting the OHS development in China. Since 1949, China has established specialized institutions for disease control and health care. In 1957, the "Regulations on the Scope of Occupational Diseases and Measures for the Treatment of Occupational Disease Patients" were issued by the Chinese government, in which 14 statutory occupational diseases were identified. In the 1980s, many OHS-associated institutions were established throughout the country, and many national and industry-level laws, regulations, and standards were issued [2]. In 1980, the "Trial Work Regulations of Occupational Disease Prevention and Control Institutes (Institutes)" [3] were issued by the Ministry of Health, and many research institutes for occupational hygiene and occupational disease prevention and control at different levels were established throughout the country. In 1981, the Ministry of Health set up the National Technical Committee on Health Standards, in which a committee was established to specialize in the standards associated with occupational hygiene and occupational disease diagnosis. In 1983, the Centre for Prevention and Treatment of Occupational Diseases and the China Occupational Safety and Health Association were established. The World Health Organization (WHO) Collaborating Committee on Occupational Health was set up in Shanghai and Beijing in the same year. The establishment of those associations and committees has effectively promoted the development of OHS in China. In 2002, the National People's Congress Standing Committee (NPCSC) issued the "Law of the People's Republic of China on Prevention and Control of Occupational Diseases" [4] and the "Law of the People's Republic of China on Work Safety" [5] to further boost and guide the OHS development in China. Meanwhile, a series of laws, regulations, and standards (such as the "Mine Safety Law of the People's Republic of China", the "Coal Mine Safety Supervision and Administration Regulations", etc.) came out to improve the OHS systems continuously and strengthen the protection of workers in various industrial sectors in China. In 2018, the National Health Commission (NHC) of the People's Republic of China was formally established to take charge of the country's health endeavors. It is observed that Chinese governments at all levels have made various efforts to promote the OHS development and improve China's occupational health and safety systems continuously in the past decades.

According to the statistics from the National Health Commission of the People's Republic of China (NHC, http://www.nhc.gov.cn/ (accessed on 20 June 2022)) for the past two decades (as shown in Figure 1), the number of new cases of occupational diseases reported nationwide increased with fluctuations from 2005 to 2016. China's industries (especially heavy industries) were developing rapidly during this period, and the most complete industrial system has emerged [6]. With the rapid industrialization, more and more occupations were involved in the industrialization process. As a result, an increasing trend of new cases of occupational diseases from 2005 to 2016 is observed. However, as the Chinese government put a lot of effort into occupational disease prevention and control, for instance, a series of laws, regulations, and standards came out to facilitate occupational disease prevention and control, and new technologies and equipment in different fields were applied to prevent occupational diseases, a decreasing trend occurred after 2016. In 2015–2016, the National Occupational Disease Prevention and Control Plan was implemented to emphasize the prevention and treatment of occupational diseases, which shows that occupational disease prevention and control in China entered a new era. After that, more occupational disease prevention- and control-related policies/standards were implemented to regulate and improve the OHS development in China, resulting in a gradual decline in the number of new occupational diseases between 2016 and 2022. Nonetheless, the number of new cases still exceeded 10,000 in 2022, indicating that the country is still facing serious challenges in the prevention and treatment of occupational diseases.

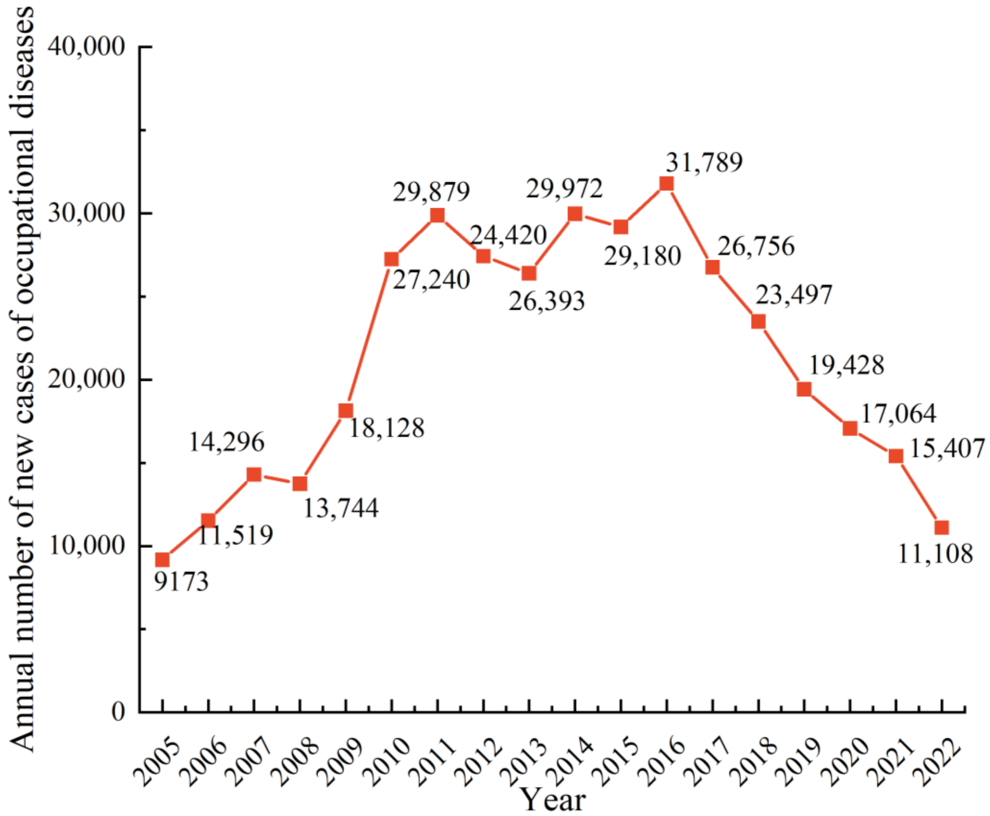

Figure 1. Number of new cases of occupational diseases per year.

Occupational disease prevention is a key research topic in the OHS domain, and the main occupational diseases in China can be divided into nine types [7], including occupational pneumoconiosis and other respiratory diseases (of which pneumoconiosis accounts for the vast majority), occupational ENT (ear–nose–throat) diseases, occupational infectious diseases, occupational chemical poisoning, etc. Mining industry, construction and materials industry, and metallurgical industry are the major industrial sectors threatened by occupational pneumoconiosis due to their harsh production and working environment [8]. Noise-induced deafness is the most common occupational ENT disease, and the noise sources are generally industrial noises (mechanical noise, electromagnetic noise, air noise, etc.). Noise-induced hearing loss often occurs in manufacturing [9], aviation [10], foundry [11], mining [12], and service [13] industries. In terms of occupational infectious diseases, brucellosis is the most common disease, accounting for more than 80% [14]. Brucellosis mainly occurs in pharmaceutical production enterprises [15], and occupational personnel engaged in breeding and processing are the susceptible population [16,17]. Acute occupational poisoning mainly occurs in the chemical [18], metallurgical, and non-ferrous metal industries [19,20]. Chronic occupational poisoning occurs frequently in the machinery, electronics, and non-ferrous metal industries [19–21]. Benzene poisoning dominates chronic occupational poisoning, accounting for 29.2%, followed by lead poisoning (27.11%) and arsenic poisoning (19.73%) [14]. CO and H_2S are the primary hazardous chemicals that cause acute occupational poisoning, and they account for more than 50% [19]. Other occupational diseases also happen in various industries and challenge the OHS development in China, such as occupational diseases caused by physical factors, occupational skin disease, occupational tumors, occupational eye diseases, and occupational radiation diseases. A summary of common occupational diseases in different industrial sectors is demonstrated in Table 1.

Table 1. Common occupational diseases in different industrial sectors.

Industrial Sectors	Common Occupational Diseases								
	OPR	**OENT**	**OI**	**OP**	**OPF**	**OS**	**OT**	**OE**	**OR**
Mining industry	√	√		√	√	√	√		√
Manufacturing industry	√	√	√	√	√	√	√	√	√
Electricity, heat, gas, and water production and supply industries	√	√		√	√		√		√
Transportation, storage, and postal service industry		√		√	√	√		√	
Scientific research and technology services industry	√	√	√	√	√	√		√	√
Water conservancy, environment and public facilities management industry			√	√	√	√			√
Resident services, repair, and other services		√	√	√	√	√		√	
Agriculture, forestry, animal husbandry, and fishery			√	√	√	√		√	
Construction industry	√	√		√	√			√	
Health and social work		√	√	√	√		√	√	√
Accommodation and catering industry	√	√			√				
Wholesale and retail industry	√			√	√				

Note: "√" indicates that this disease category exists in this sector. OPR = occupational pneumoconiosis and other respiratory diseases; OENT = occupational ENT disease; OI = occupational infectious diseases; OP = occupational poisoning; OPF = occupational diseases caused by physical factors; OS = occupational skin disease; OT = occupational tumors; OE = occupational eye diseases; OR = occupational radiation diseases. The industry classification is derived from the "Risk Classification Management Catalogue of Occupational Disease Hazards of Construction Projects" [22]. The possible occupational diseases in each industry are derived from the "Occupational Hazard Factors Existing in Common Industries" [23].

The National Health Commission of the PRC [24] has formulated "the National Occupational Disease Prevention and Control Plan (2021–2025)" to promote "Healthy China 2030". Under the guidance of this plan, it is expected that the OHS in China will reach a new level by 2025. According to the "Statistical bulletin of human resources and social security development in 2021" [25], the employed population in China at the end of 2021 reached 74.652 million. A very large number of employed population also brings enormous challenges to the OHS development in China. Although remarkable progress and achievements have been made in terms of OHS in China, the demand for improving occupational disease prevention and control in China is still strong [26,27]. At present, occupational health issues caused by workplace exposures remain serious. The prevention and control of occupational diseases are challenging, particularly, emerging occupational health issues (for instance, psychological problems caused by work-related stress) have become tricky problems that require urgent attention. Additionally, because China has entered a new planning period for OHS, some unique requirements should be met to lift the OHS level. Therefore, a systematic and thorough review is needed to gain insight into the development process, current status, and research needs/gaps regarding OHS in China and further investigate the future pathways for boosting the OHS development considering the new requirements of the new era. Typically, a specific aspect/topic of the OHS was reviewed by previous studies, for instance, the occupational health and safety countermeasures in Beijing were reviewed in [28], research progress on occupational noise-induced deafness was investigated in [29], and research progress on the occupational health and personal protection of emergency responders were reviewed in [30]. However, a thorough literature review of the Chinese OHS development is still lacking currently. A systematic review of OHS in China is needed to gain insight into the overview of the Chinese OHS development from a multidisciplinary perspective. As a result, a bibliometric analysis is employed in this paper to achieve our research objectives by answering the following four questions. (i) What are the data characteristics of the publication temporal distribution and productive journals? (ii) What are the characteristics of productive organizations, productive authors, and their collaborative networks? (iii) What are the hot research topics and dominant methodologies, and what are their evolutionary trends? (iv) What are the research needs/gaps and the possible research pathways for boosting the OHS development in China? A systematic and comprehensive review of the OHS development in China is formulated by answering those questions one by one with the help of the bibliometric analysis.

2. Methodology

2.1. Method and Retrieval Process

This study employs a bibliometric analysis to investigate the development process, research status, and research trends of OHS in China. Bibliometric analysis is a comprehensive method combining mathematics and statistics, which enables a quantitative analysis of a specific research field [31]. It can capture the cooperative relationships and co-citation similarities based on some basic measurement objects (for instance, the number of articles, publishers, authors, institutions, etc.) [32]. Many researchers have applied bibliometric analysis to conduct literature reviews regarding different topics, such as process safety in China [33], economic development and technological security [34], and so on. Compared to other analytical methods (such as meta-analysis) [35,36], bibliometric analysis has the advantage of assessing the nonempirical outcome relationship of articles and focusing on article attributes (such as publication mode, author, and keywords) and their relationships with each other.

In this study, the Web of Science Core Collection (WoSCC) and the Chinese Science Citation Database (CSCD) were used as the databases for publication search. The time range for searching was set as Oct 1979 to Dec 2022. A search statement (keywords "occupational health and safety*" OR "occupational disease*" OR "occupational hazards*" OR "occupational risk*") AND "China" are used. The keywords used in the search statement are the common keywords used in OHS-related studies. The search statement was formulated according to the logical relationship of the keywords. A total of 233,637 records were derived under this search condition. By implementing several constraints (publication regions were selected as Mainland China, Hong Kong, Taiwan, and Macau; publication language was set as Chinese and English; research papers, review papers, and conference papers were selected) to refine the database, 16,868 records were obtained. Two authors took the responsibility of manual screening based on the titles and abstracts of the collected publications. Both of the authors performed a primary literature screening independently to filter obviously irrelevant publications, and then, the primary results were double-checked by the two authors together to determine the final selected publications. If the relevance of the paper was not clear from reading the title and abstract, we read the full text to make sure that it is relevant to our research scope. Finally, 5675 records were obtained. The publication data retrieval process is shown in Figure 2.

2.2. Bibliometric Analysis Tool

VOSviewer was used in this study to perform the bibliometric analysis and visualize the statistical results. VOSviewer was developed by van Eck and Waltman [37], and it is capable of generating text maps and performing a variety of document analyses [38]. Due to its powerful functionalities in terms of literature visualization and quantitative analysis, the VOSviewer has been widely used in many literature review articles [39–42].

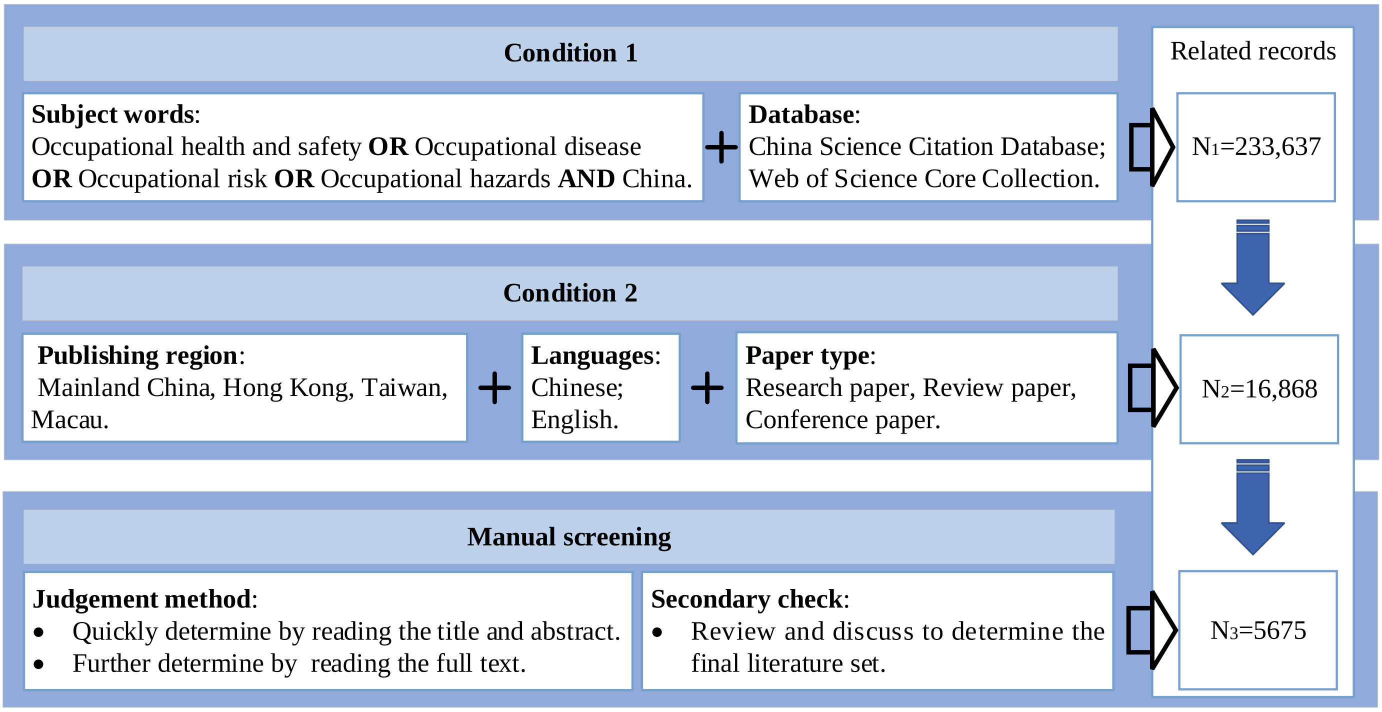

Figure 2. Data retrieval process of the publication database.

3. Result and Discussion

3.1. The Temporal Distribution of the Publications

Based on the obtained 5675 publications, the temporal distribution and cumulative distribution of the publication numbers are presented in Figure 3. As shown in Figure 3, the number of papers follows an increasing trend with fluctuations. Before 2001, the number of publications was relatively stable. In 2001, China joined the WTO (World Trade Organization). While speeding up the country's economic development, the annual number of OHS-related publications began to increase significantly. China issued the first national occupational disease prevention and control plan (NODPCP) in 2009, and under the guidance of this plan, OHS-related research shows a clear growth trend after 2009. In 2016, the second NODPCP was implemented, which further increased the research interest in OHS. As a result, the number of publications increased continuously. From 2019 to 2022, COVID-19 broke out in many countries and regions around the world. China was the initial outbreak site, and the COVID-19 pandemic had a significant impact on the Chinese OHS. As shown in Figure 3, a large number of relevant publications were published by Chinese researchers to study occupational health and safety issues under the impact of COVID-19. As the pandemic was under control, the number of COVID-19-related publications showed a decreasing trend between 2021 and 2022. However, given the significant impact of the COVID-19 pandemic on occupational health and safety research, it is predicted that there will still be some relevant publications in the subsequent years. Meanwhile, with the implementation of the third NODPCP in 2021, occupational diseases in the context of COVID-19 are predicted to become the focus of future research. Additionally, there are some new needs for the development of occupational health and safety in China, which has entered a new era in terms of occupational health development. With respect to emerging needs and policy planning, it is expected that the number of relevant papers will remain at a high level in the future.

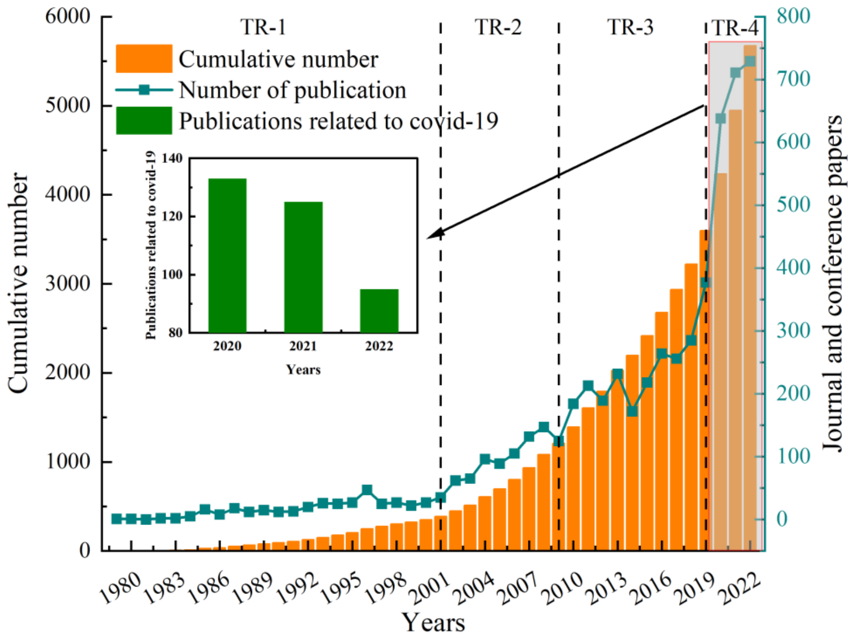

Figure 3. Temporal distribution and cumulative distribution of publications (TR in Figure 3 means time region).

3.2. Source Journal Analysis

According to the obtained publication database, 5675 articles were published in 1345 journals. The source journals cover diverse topics, including public environmental occupational health, general internal medicine, toxicology, and other research domains. Thirty-four journals have published more than 30 publications, and those journals are called "active journals". Table 2 lists the top ten prolific journals with respect to OHS in China, including two Chinese journals and eight international journals. The *Chinese Journal of Environmental Occupational Medicine* (CJEOM) has the most publications (316), and it mainly focuses on epidemiological and toxicological contents associated with environmental factors, occupational health, and population health. The second prolific journal is the *Chinese Journal of Nosocomiology* (CJN) with 254 publications. CJN is a professional journal dedicated to infection prevention and control, infectious disease prevention, and biosafety protection. The *International Journal of Environmental Research and Public Health* (IJERPH) has the highest TP (total number of publications) among all international journals. Its scope covers environmental sciences and engineering, public health, environmental health, etc. The *American Journal of Industrial Medicine* (AJIM), with 106 publications and 2931 citations, has played a key role in expanding the influence of the related research. AJIM mainly focuses on occupational health and safety. *PLoS One* and *Occupational and Environmental Medicine* (OEM) also have high citation rates. OEM has the highest impact factor (IF) and the second-highest average number of citations (AC). The *Journal of Occupational and Environmental Medicine* (JOEM, 15.06), *Journal of Occupational Health* (JOH, 16.16), and *BMC Public Health* (16.09) have similar AC numbers. The TP rates of the *International Archives of Occupational and Environmental Health* (IAOEH) ranks ninth in Table 2. By contrast, its TC (total number of citations) and AC rank fifth and fourth, respectively. From the results shown in Table 2, it can be observed that more international journals are in the prolific journal list but not Chinese journals. One reason is that Chinese researchers prefer to publish their research works in well-recognized international journals because international journals are more likely to be shared by researchers around the world. Another reason is that the number of Chinese journals tracked by the CSCD focusing on the OHS-associated research is less compared to the international journals tracked by the WoS. As a result, both international journals and Chinese journals became important platforms for sharing and communicating the OHS-associated research for Chinese scholars.

Table 2. Top 10 prolific journals on occupational health and safety in China.

Rank	Journal	TP	TC	AC	IF
1	*Chinese Journal of Environmental Occupational Medicine* (CJEOM)	316	433	1.37	1.403
2	*Chinese Journal of Nosocomiology* (CJN)	254	824	3.24	1.963
3	*International Journal of Environmental Research and Public Health* (IJERPH)	238	2090	8.78	4.614
4	*American Journal of Industrial Medicine* (AJIM)	106	2931	27.65	3.079
5	*Journal of Occupational and Environmental Medicine* (JOEM)	95	1431	15.06	2.306
6	*PLoS One*	92	2004	21.78	3.752
7	*Occupational and Environmental Medicine* (OEM)	84	2166	25.79	4.948
8	*Journal of Occupational Health* (JOH)	80	1293	16.16	2.57
9	*International Archives of Occupational and Environmental Health* (IAOEH)	80	1454	18.18	2.851
10	*BMC Public Health*	74	1191	16.09	4.135

Note: TP = total number of publications; TC = total number of citations; AC = average number of citations; IF = impact factor; the IF refers to the latest information available on the CNKI (China National Knowledge Infrastructure) and WoS.

3.3. Cooperation Network Analysis

3.3.1. Cooperation Network of Chinese Institutions

A total of 38 domestic institutions have more than 59 publications (i.e., more than 1% of the publications). Table S1 in Supplementary Materials shows the top 15 most prolific Chinese institutions in this field, all of which have more than 100 publications. The total number of the publications from those institutions reaches 1838 (i.e., more than 32.4% of all the publications). A total of 43,673 citations (i.e., more than 50.4% of all the citations) belong to those publications. It means that those institutions have dominated this research field. The Chinese Center for Disease Control Prevention (CCDC) ranks first in terms of both the number of publications (287) and citations (7674). FUDAN (Fudan University,) and HUST (Huazhong University of Science Technology) occupy the second and third positions, with 224 and 195 publications, respectively. HUST (5891) and FUDAN (5200) rank at the second and third positions in terms of TC, respectively. There are 13 colleges/universities among the top 15 most prolific institutions. It shows that domestic colleges/universities contributed a lot to the development of OHS in China. Additionally, most of these research institutes are located in economically developed or higher-level provinces/cities. The prestige and reputation of the research institutions are one of the reasons for promoting domestic and international cooperation, raising the profile of research results, and increasing the number of research outputs.

To explore the collaboration network between the productive institutions, the co-authorship analysis was used to visualize the collaboration network diagram, as shown in Figure S1. Based on the network diagram, seven clusters were identified. The color of the sphere indicates the cooperative cluster to which the institution belongs. The spheres' sizes represent the strength of the institution's ties in the collaborative cluster, and a larger sphere represents more collaborations. A line between two spheres represents the connection between the institutions.

In Figure S1, cluster #1 is centered on the CCDC, HUST, and CUHK. Research institutions in this cluster are from the mainland and Hong Kong. In cluster #2, NMU (Nanjing Medical University) takes the dominant position. In cluster #3, PKU and CMU (Capital Medical University) are dominant, and the majority of the institutions in this cluster are located in northern China. Cluster #4 has FUDAN as the dominated institution. The institutions in cluster #5 are from Taiwan. In this cluster, NTU, KMU, and NCKU (National Cheng Kung University) are prolific institutions. Research institutions in Taiwan have a strong collaboration with CMU and CMUT, which are two institutions in mainland China. The above results show that the institution collaborations are throughout China, among which Taiwan and mainland China have the closest cooperation, followed by Hong Kong and Macau. It can be seen that Chinese institutions have an excellent domestic cooperation relationship in terms of OHS. In addition, these clusters can be characterized in two ways. One is clearly regional, with a high level of regional institutions leading the cooperation with other institutions in the region, as in cluster #5. The other is supra-regional cooperation under the leadership of multi-central institutions, as in clusters #1 to #4. In addition, these leading institutions are basically located in economically developed provinces, which is also in line with the results shown in Table S1.

3.3.2. Cooperation Network of Prolific Authors

In this section, we listed the top 10 productive authors and their research interests in Table S2. The collaborative network of the authors is visualized by using the VOSviewer, as shown in Figure S2.

Among Chinese scholars in Table S2, Xia ZL ranks first with 51 papers. Xia ZL is a professor at the School of Public Health, FUDAN, specializing in the risk assessment and prevention of genetic damage in workers exposed to chemical carcinogens. The second position belongs to Zheng, Y.X., who is affiliated with the School of Public Health, QU, NIOHPC, and CCDC. Both Li, G.L. and Yin, S.N. are from CCDC, and they rank third and fourth, respectively. Their main research focus is benzene poisoning. According to the ranking of TC, 45 papers of Li, G.L. have been cited 3045 times, which is the highest number of citations in Table S2. Yin, S.N. and Zhang, L.P. rank the second and third places with 3020 and 1774 citations, respectively. The three scholars also occupy the top three positions in terms of AC, indicating that their research is widely recognized by other scholars. According to the research topics of those prolific scholars, we can see that the research directions are quite diverse. The research directions of the prolific scholars include but are not limited to occupational disease epidemiology [43], occupational psychology and stress [44], occupational exposure assessment and prevention [45,46], health toxicology [47], etc. The collaboration network of the prolific scholars is visualized in Figure S2. Obvious connections between the prolific authors in Table S2 can be found in Figure S2. The mutual cooperation between them further expands the research influence, which is also evidenced by the high citation rates in Table S2.

3.3.3. International Cooperation Network

In this section, the international cooperation network associated with the OHS development in China is investigated. Main countries, international institutions, and scholars collaborated with Chinese scholars and institutions were identified. A total of 76 countries and regions (excluding Hong Kong, Macau, and Taiwan) have collaborated with Chinese scholars/institutions on the research topics associated with OHS.

Table S3 in Supplementary Materials lists the top 10 foreign institutions actively participating in the research associated with OHS, collaborating with Chinese institutions/scholars. Among those institutions, nine institutions are from the US, and one is from The Netherlands. This is proof enough that the United States is China's main cooperating country (see Table S3). The NCI ranks number one with 114 publications. It is followed by Harvard (with 101 publications), UC (with 79 publications), etc. As shown in Table S3, the TP of the top five institutions exceeds 2000, and the AC of them exceeds 50 times except for Harvard University. In addition, five universities are listed in Table S3. A total of five UC branch universities have participated in the research associated with OHS and collaborated with Chinese scholars, and UC Berkeley (with 42 publications) is the most active university among them. UU is the only institution from the top 10 that is not from the US. In addition, the main Chinese institutions collaborating with foreign institutions can be observed in Table S3. There are seven foreign institutions in cooperation with FUDAN. CCDC has cooperated with six foreign institutions on the OHS-associated research. HUST, CUHK, SPPH, GPCC, and PKU have cooperated with two foreign institutions, and the remaining institutions have cooperated with one foreign institution.

The top five foreign scholars who have the most cooperative publications with Chinese scholars are identified in Table S4. Prof. Christiani is the foreign scholar who has the most cooperative papers with Chinese scholars on OHS. His research mainly focuses on the occupational diseases and occupational exposures of cotton spinning workers [48] and mining workers [49]. Rothman has published 55 cooperative publications with Chinese scholars. The topics of his cooperative publications are mainly occupational benzene exposure [50]. In addition, Prof. Dosemeci and Prof. Vermeulen take the third and fourth places. Prof. Dosemeci mainly studies the cancer risk of workers exposed to benzene or silica [51]. The health risks of worker exposure to benzene are also the main research topic of Prof. Vermeulen, who is also interested in the research on health risks caused by other carcinogens (trichloroethylene, formaldehyde, diesel engine exhaust, etc.) [52]. Prof. Checkoway has 32 cooperative publications with Chinese scholars on OHS. His research mainly focuses on the cancer risk of female textile workers [53].

3.4. The Main Research Topics

To identify the main research topics related to the Chinese OHS, a bibliographic coupling analysis was performed. Figure 4 shows 86 papers that have been cited at least 90 times, and the identified publications are divided into 10 clusters. Bibliographic coupling occurs when two publications share the same references. Therefore, the main topics of each cluster can be identified by investigating the publications of the scholars presented in Figure 4. The research theme of cluster #1 is centered on COVID-19. The psychological problems of Chinese medical staff during the epidemic were mainly studied by the researcher in cluster #1. Researchers in cluster #2 have mainly investigated the influence of SARS on the psychology of Chinese medical staff. By contrast, the research topics of cluster #3 include back pain and psychological risks of practitioners, especially nurses. The research topics of cluster #4 are associated with the adverse impacts of benzene exposure on occupational populations. The research topics of cluster #5 mainly include the risks caused by exposure to chemical gases and the effects of air pollution on the population's occupational health. The research topics of cluster #6 are mainly related to occupational health in the construction industry. Cluster #7 mainly focuses on the connections/relationships between job security/climate and occupational health. The impact of job stress on occupational safety and health was also studied by the researchers in this cluster. By contrast, cluster #8 mainly focuses on the occupational exposure-induced lung cancers of miners. Two main topics were investigated by the researchers in cluster #9, which are the HIV/AIDS risks of special occupational groups (such as sex workers) in China and the adverse effects of X-rays on medical diagnostic workers. Scholars in cluster #10 mainly focus on the health of workers under long-term occupational exposure to silica, heavy metal dust, and the associated zinc oxide nanoparticles. The above results show that the research topics associated with OHS investigated by Chinese researchers are quite diverse. Many research topics have been studied, such as occupational disease prevention, psychological health, physical health/safety, occupational exposure, health risks, etc.

3.5. Research Topic Evolution Analysis

To understand the research topic evolution in recent decades, the co-occurrence module in the VOSviewer was used to analyze the keywords of the collected publications. First, four time regions were used to categorize those publications: (i) before 2001, (ii) 2001–2008, (iii) 2009–2018, and (iv) 2019–2022. Then, the main research topics were identified from the keywords of the corresponding publications in each time region.

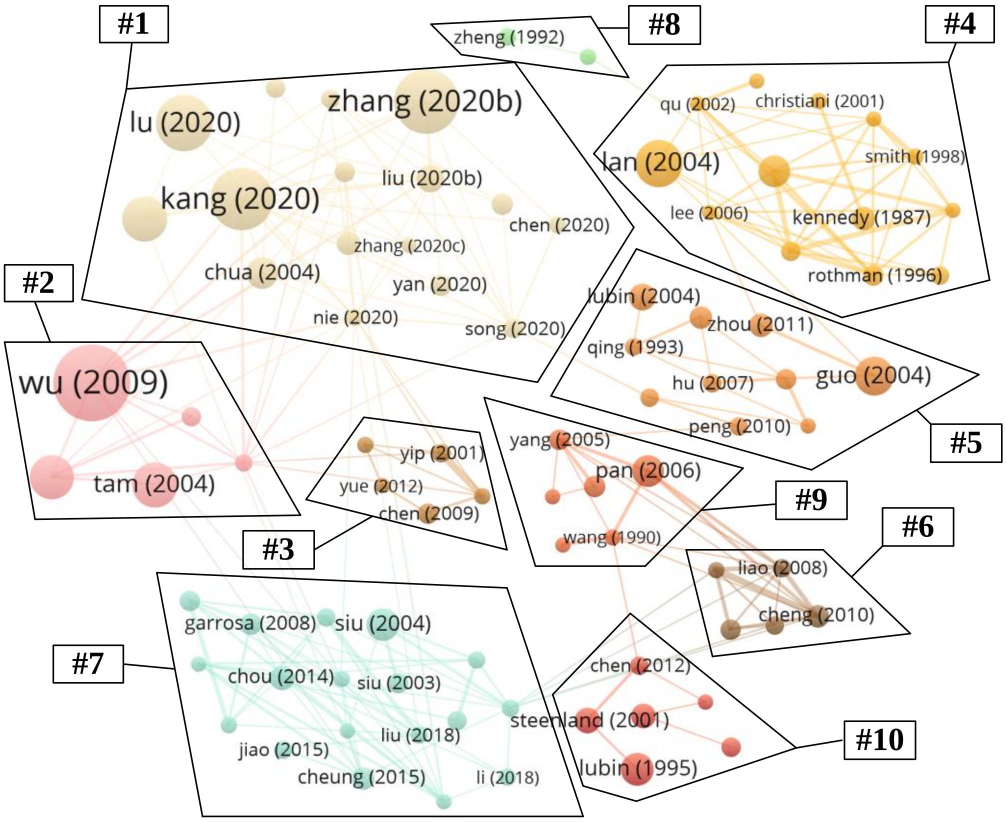

Figure 4. Bibliographic coupling analysis network of occupational health and safety in China (the circles represent publications, and their size depends on the number of citations the publication has received. The number in parentheses indicates when this key document was published.).

3.5.1. Research Topics before 2001

As shown in Figure 5, "occupational exposure" is the keyword that lasted the longest time in this time span among the top 10 keywords. Occupational exposure (OE), as one basic cause/factor leading to occupational diseases, has been a key topic in the prevention and control of occupational diseases for a long time. Common OE mainly includes metal exposure [54], dust exposure [55], chemical gas exposure [56], nuclear exposure [57], etc. "Smoking" is the second hot research topic in this time span. Related studies on "smoking" demonstrate that smoking is a key factor to exacerbate occupational exposure adverse impacts [58,59]. "Benzene" is the third hot topic. Benzene-associated papers mainly focus on the adverse impacts of benzene [60,61]. Cancers, such as lung cancer [62] and leukemia [63] were the main subjects of the studies during this period. In addition, "pulmonary function", "silicosis", "asbestos", and "respiratory symptoms" are also hot research topics in this time span.

3.5.2. Research Topics from 2001 to 2008

Figure 6 shows the most frequent research keywords from 2001 to 2008. It can be observed that OE is still the dominant keyword. Metal exposure, dust exposure, and other types of exposure were still hot research topics. The next hotspot keyword is "lung cancer", which is a research topic highly correlated to OE. There are many causes that may lead to lung cancer in the working environment. For instance, long-term exposure to asbestos [64], polycyclic aromatic hydrocarbons (PHAs) [65], silica [66], secondhand smoke [67], etc. In addition, OE is also a major cause of "pneumoconiosis". During this period, many researchers investigated the occupational health of textile workers [68,69]. It reflects that the textile industry was one of the main industries threatened by occupational diseases.

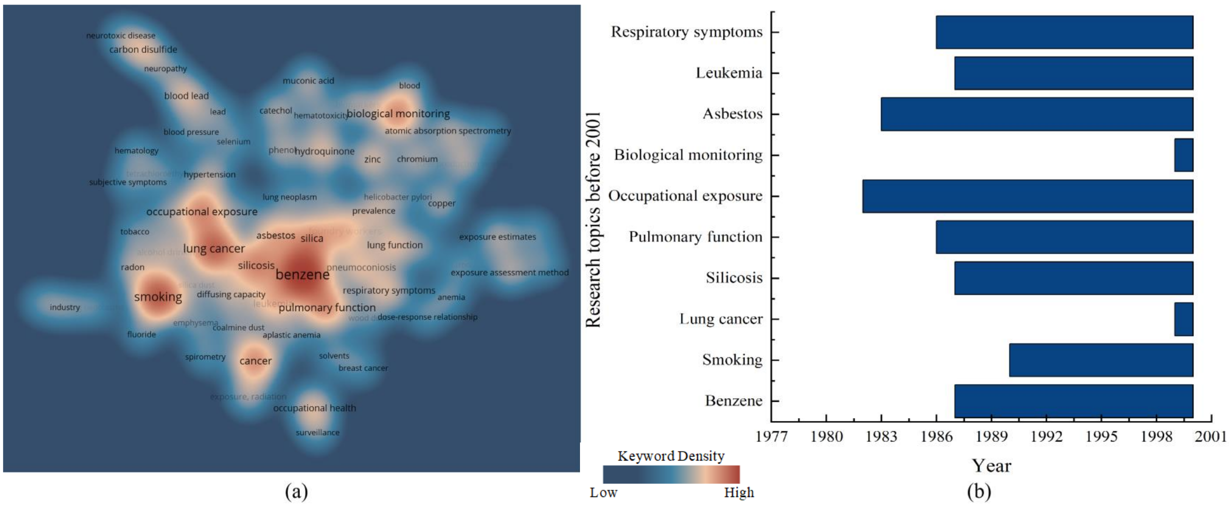

Figure 5. Density view and time span of main research topics on occupational health and safety in China before 2001 ((**a**) depicts the density distribution of the keywords, and (**b**) presents the top ten keywords in this time region).

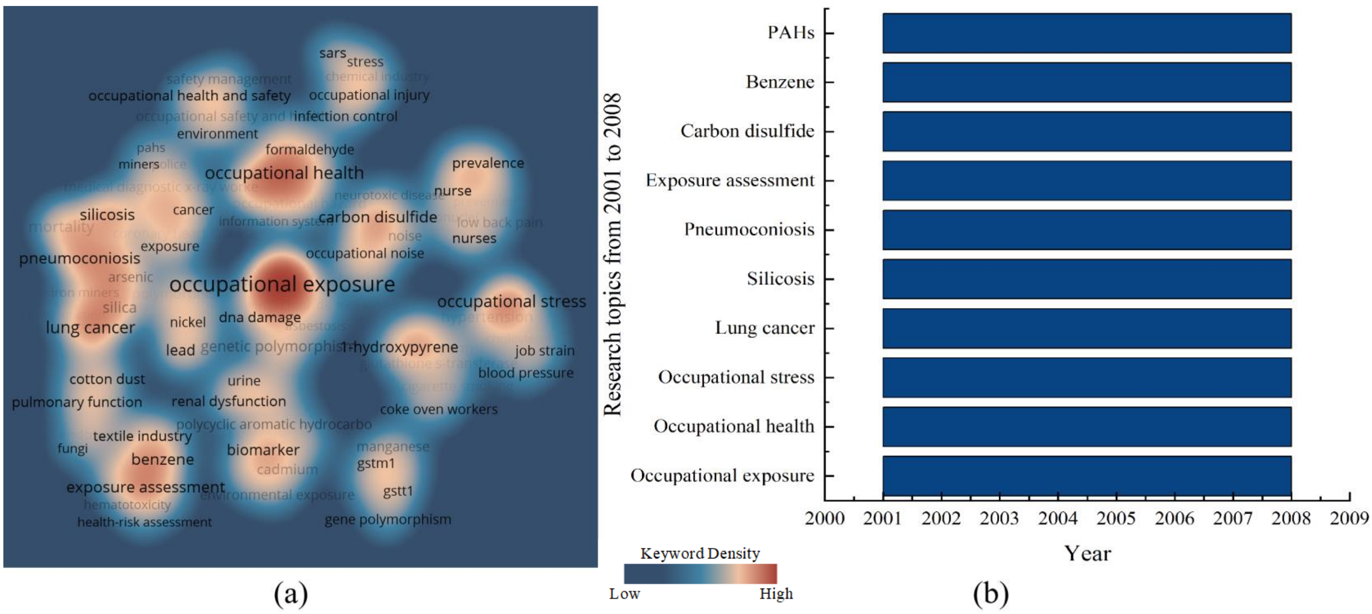

Figure 6. Density view and time span of main research topics on occupational health and safety in China from 2001 to 2008 ((**a**) depicts the density distribution of the keywords, and (**b**) presents the top ten keywords in this time region).

Exposure assessment was also a research focus during this period. Exposure assessment associated with benzene and PAHs was mainly investigated. For example, Vermeulen et al. [70] conducted a detailed exposure assessment of benzene in two shoe factories in Tianjin, China. Chen et al. [71] evaluated the inhalation and dermal exposure of workers with respect to PAHs. In 2002, SARS broke out in Guangdong, China. As a result, the OHS of medical staff became a hot research topic during this period. The research keywords, "SARS", "infection control", "stress" and "occupational injury", are all probably associated with this event. Tam et al. [72] revealed that hospital administrators need to pay more attention to the physical stress and psychological distress among healthcare workers during disease outbreaks. Lau et al. [73] found out that insufficient supply of PPE (personal protective equipment), lax infection control training, and improper use of PPE were the critical risk factors for SARS infection. An experiment conducted by Chen et al. [74]

showed that nurses were suffering from moderate psychological distress during the SARS epidemic.

3.5.3. Research Topics from 2009 to 2018

As shown in Figure 7, "occupational exposure" was still the most popular research topic during this period. The occupational exposures of healthcare staff were mainly investigated in this period, such as blood-borne occupational exposures [75,76] and primary sharps injury [77]. In 2009, the Chinese government [78] delivered the national occupational disease prevention and control plan (2009–2015). The prevention and control of pneumoconiosis, occupational poisoning, and occupational radiation diseases are highly emphasized in this plan. Occupational exposure is one of the main causes for such occupational diseases. Liu et al. [79] concluded that exposure time and job scopes were the two most important factors associated with pneumoconiosis of coal miners. Liu et al. [80] demonstrated that manufacturing workers with severe toxic encephalopathy may be caused by occupational exposure to 1,2-Dichloroethane. Qian et al. [81] suggested that the occupation, exposure time, and equivalent dose may increase the risk of the unstable genetics of radiologists. The second hot research topic is "occupational health". According to Chen et al. [82], the lack of collaboration among company staff is the most likely factor that leads to the failure of the occupational health and safety administration system (OHSAS). Ren [83] suggested that China should gradually improve the OHS legislation and establish an independent legal system considering the actual national conditions. The "National Occupational Disease Prevention and Control Plan (2016–2020)" [84] also suggested strengthening the construction of laws and regulations in relation to occupational disease prevention. The third key research topic is "occupational stress" during this period. Job/occupational stress may cause serious damage to the physical and mental health of workers [85]. Zhong et al. [86] investigated Chinese university teachers and found that burnout may lead to depression and poor physical health of teachers. Wu et al. [87] conducted a survey on medical staff in Fujian Province, and it was found that occupational stress was one of the main factors affecting the sub-health status of medical staff. In addition, musculoskeletal disorders (MSDS) in the vicinity of occupational health in Figure 7 are also worth discussing. Currently, more than 1.7 billion people worldwide are suffering from MSDS, with 33% of patients suffering from low back pain [88]. In China, 16.4% of workers in main industrial sectors are also suffering from low back pain [89]. In this regard, some technologies, such as postural risk assessment [90] and ergonomic assessment [91] may be investigated to prevent and control the risks of MSDS.

3.5.4. Research Topics from 2019 to 2022

Figure 8 shows the research hotspots during this period. "COVID-19" was the hottest research topic during this period. In the early period of the COVID-19 epidemic, some medical staff inevitably experienced psychological problems [92,93]. Moreover, new occupational exposure risks may emerge with post-exposure infections [94]. Pan et al. [95] recommend some measures to reduce infection risks by keeping hand hygiene and physical distance for factory workers. Liu et al. [96] suggested that companies should take effective measures to reduce employee burnout and promote safe behaviors considering the prevention of the spread of epidemics. Duan et al. [97] recommend improving the design of PPE of healthcare personnel and improving the services to COVID-19 patients. In addition, Zhang [98] put forward some countermeasures for the medical personnel in response to public health emergencies based on the analysis of the policies issued during the COVID-19 epidemic.

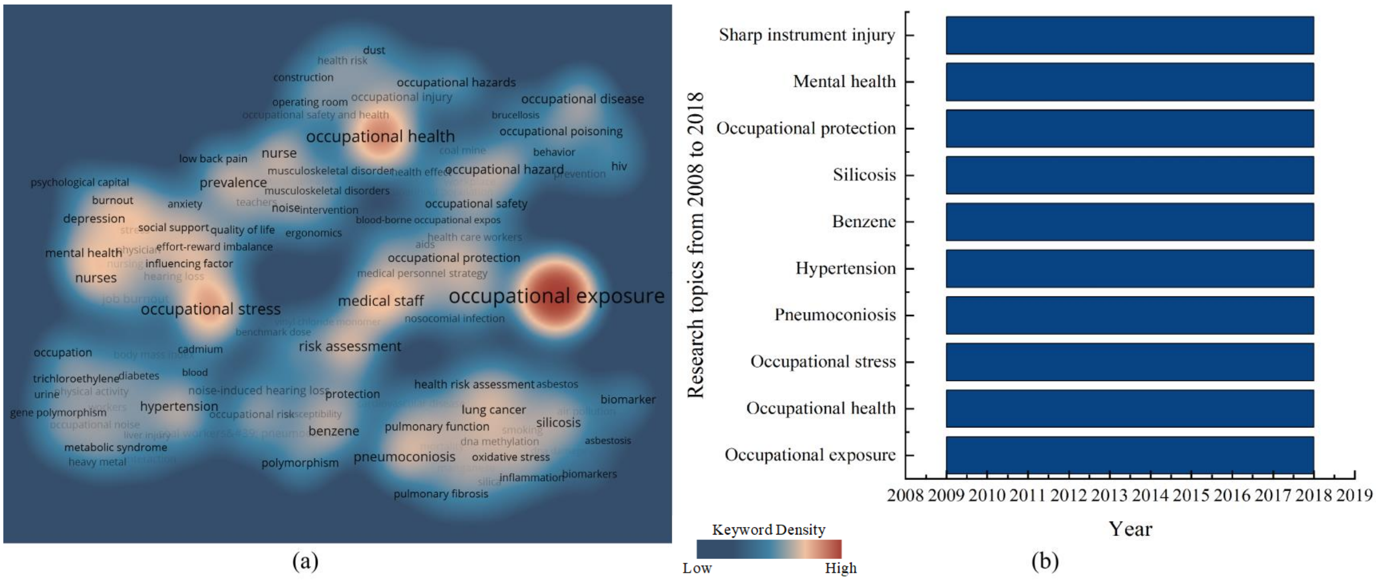

Figure 7. Density view and time span of main research topics on occupational health and safety in China from 2009 to 2018 ((**a**) depicts the density distribution of the keywords, and (**b**) presents the top ten keywords in this time region).

The new version of the "International Classification of Diseases" has officially entered into force in January 2022 [99]. In this document, "burnout" is defined as a chronic disease, which is a conceptual psychological syndrome caused by the chronic inability to successfully overcome workplace stress. As a new occupational disease, burnout has widely affected the physical and mental health of professionals. In the context of the global prevalence of COVID-19, the occupational crowd is more prone to burnout [100,101]. Some scholars studied the factors in relation to occupational stress and occupational burnout. Zhou et al. [102] found that job satisfaction and mental health are the most important influencing factors leading to a higher incidence of job burnout among Chinese leprosy control workers. Wu et al. [103] proposed that perceived social support and job satisfaction have a mediating effect on job stress and job burnout. Yu and Li [104] found that the mediating effect on job stress and job burnout can reduce miners' unsafe behavior. These results reflect the correlations between occupational stress and burnout.

Currently, occupational/job stress has become the cause of many physical or mental illnesses and even death. Common issues under the influence of occupational stress include insomnia [105–107], hypertension [108,109], depression [110,111], coronary heart disease [112], and even suicide [113]. Although occupational stress is not defined as an occupational disease in all countries, existing research has revealed that both occupational stress and recognized occupational diseases (pneumoconiosis, occupational poisoning, etc.) are the factors that may cause serious consequences. Ge et al. [114] found that occupational stress is common among copper-nickel miners and has become an important factor to reduce their life qualities. Wang et al. [115] conducted a study on nonclinical essential workers during the COVID-19 epidemic and found that a large number of deaths were associated with overworking.

During this period, more methods and techniques were applied to the assessment of MSDS. For instance, Lin et al. [116] calculated risk scores regarding MSDS based on joint angle information obtained using an image-based motion capture technology. Dong et al. [117] analyzed the patterns of multisite musculoskeletal symptoms and their relationship with ergonomic factors by using the latent class analysis and multinomial logistic regression models. In addition, human factors are mentioned more frequently in the studies associated with occupational safety management [118–120].

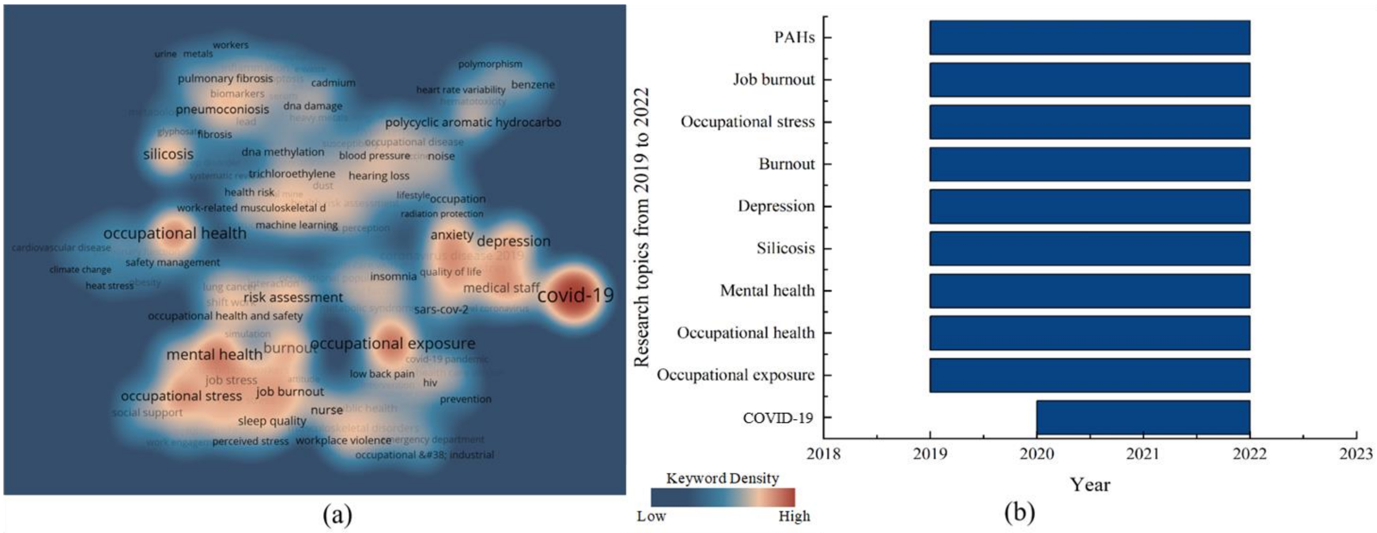

Figure 8. Density view and time span of main research topics on occupational health and safety in China from 2019 to 2022 ((**a**) depicts the density distribution of the keywords, and (**b**) presents the top ten keywords in this time region).

According to the research topic evolution process, it is observed that occupational exposure is always a key research topic during the past decades. Because some professions are unavoidably exposed to hazardous materials, for instance, the exposure to dust and toxic chemicals in industrial sites, the assessment and control of occupational exposure plays an important role to ensure the occupational health of workers. Additionally, the research on new/emerging occupational diseases shows an increasing trend. With the development of society, the outbreak of black swan events and new types of occupational risks have gained more and more attention. For instance, occupational diseases in relation to job stress and pandemic infectious diseases. Accordingly, new technologies and new legislative protections may be investigated to ensure the occupational health of workers and protect the health and safety rights/interests of workers.

3.6. Research Method Evolution

To investigate the methods used in the research in relation to the OHS development in China, the main research methods are extracted from the keywords based on the database. Figure 9 shows the identified main research methods used in each period.

3.6.1. The Research Methods before 2001 (TR-1)

The epidemiological methods during this period were dominated by cohort studies. Cohort studies are important research methods for analytical epidemiology, and they can test etiological hypotheses, evaluate preventive effects, and describe the natural history of diseases [121]. In addition, other epidemiological methods (longitudinal studies, cross-sectional studies, case-comparison studies, etc.) are also used to analyze various occupational diseases. Questionnaire surveys are usually used for both data collection and brief analysis in OHS-associated studies. Spectroscopic methods are used to identify a substance and determine its chemical composition and relative content based on measuring the wavelength and intensity of radiation. Huang et al. [122] used atomic absorption spectrometry to measure whole blood and urine chromium concentrations in chrome-plating factory workers. In addition, other research methods are also used in the studies related to OHS during this period, such as survival analysis [123].

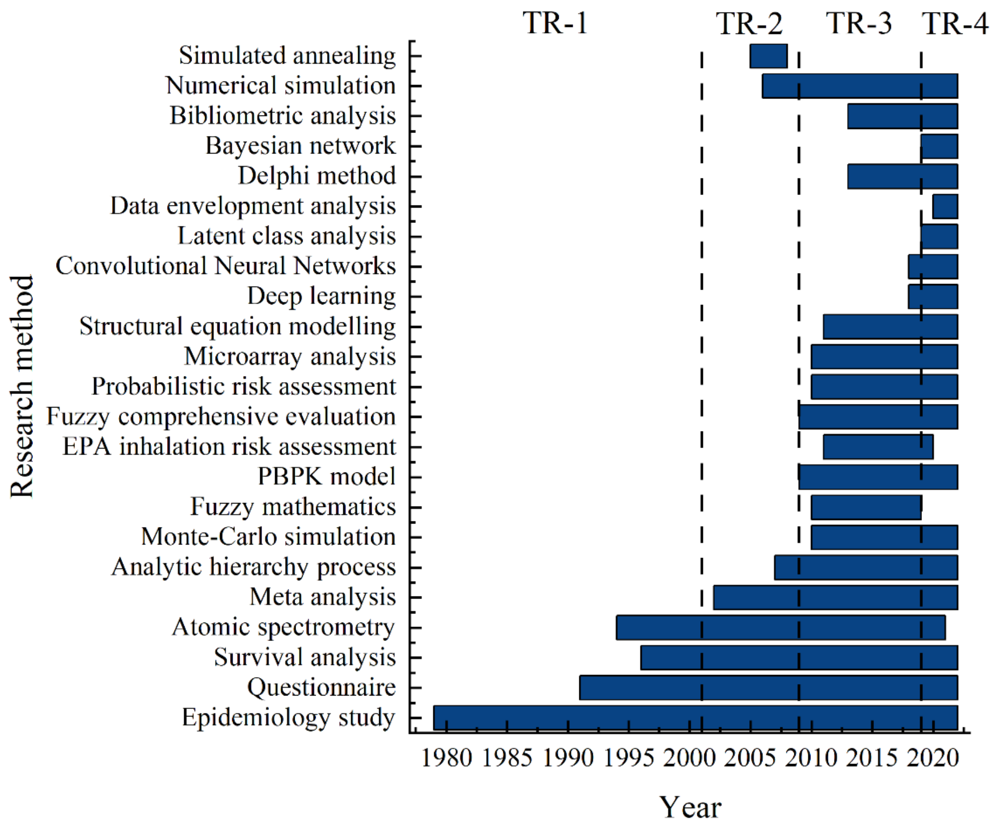

Figure 9. Time distribution of research methods of occupational health and safety in China (TR in Figure 9 means time region).

3.6.2. The Research Methods from 2001 to 2008 (TR-2)

Cohort studies and case-control studies are still the most commonly used epidemiological methods. These two methods were used to study occupational disease mortality, occupational cancer risk, and other occupational disease risks. The meta-analysis was formally proposed by Smith and Glass [124] in 1976. During this period, the meta-analysis began to be used to analyze standardized mortality ratios and to summarize scientific medical evidence. Questionnaire surveys were used in this period to generate data sources for the research on psychological influence [72], prevalence [125], etc. The analytic hierarchy process (AHP) was mainly used in this period to determine the weights of the factors of quantitative occupational safety assessment indicators [126]. Additionally, a simulation method called simulation annealing was used for noise identification and control in factories [127].

3.6.3. The Research Methods from 2009 to 2018 (TR-3)

Epidemiological methods had steady article outputs during this period. Some of these studies were conducted for more than 20 years [128] or even 40 years [129]. It can be seen that some epidemiological methods should consume an enormous amount of time to obtain highly scientific and objective conclusions. Meta-analyses were mainly employed to investigate the correlations between occupational diseases/accidents and occupational exposure in this period. Furthermore, some scholars systematically analyze the research outcomes of a certain occupational disease in a specific period through meta-analysis methods [130]. The establishment and implementation of evaluation models were widely used during this period. For example, physiologically based pharmacokinetic (PBPK) models were used in conjunction with dose–response models to assess health risks quantitatively [131]. The inhalation risk assessment models of the Environmental Protection Agency were directly applied or combined with other models for the occupational health and safety risk assessment (OHSRA). The AHP was widely used for the OHSRA. This method can determine the weight of each indicator and provide suggestions for improvement measures. Uncertainties inevitably arise when conducting the OHSRA or occupational risk assessment. Wang et al. [132] used Monte Carlo simulation and uncertainty analysis to improve the OHSRA model. In addition, the introduction of fuzzy mathematics and the establishment of a fuzzy comprehensive evaluation model also help to address the uncertainties in occupational health risks [133]. Because latent variables cannot be easily handled by traditional statistical methods, scholars used structural equation modeling (SEM) to process data [134,135]. The implementation of SEM helps to investigate the influencing factors related to the target, and both direct and indirect relations can be analyzed. Long-term occupational exposure can cause abnormal gene expression. Researchers used the microarray analysis to perform gene differential expression in blood mononuclear cells to identify key genes and explore potential biomarkers.

3.6.4. The Research Methods from 2019 to 2022 (TR-4)

Epidemiological methods are still the mainstream methods in this period. Meta-analysis was used to analyze occupational burnout [136], prevalence [137], occupational injury [138]. OHSRA models that can quantify occupational health damages gained attention in this period. In terms of uncertainty handling in the OHSRA, the use of the Delphi method, fuzzy theory, Bayesian network, and other methods helps to reduce subjectivity and address the uncertainty in risk assessment. For example, Mohandes and Zhang [139] developed an OHSRA model combining the Delphi method and fuzzy theory. Latent class analysis is used to analyze risk behavior patterns and their influencing factors. The bibliometric approach, which has gradually become popular from TR-3, also facilitates the systematic analysis of research status related to this field and provides new research insights. Additionally, the development and implementation of artificial intelligence technologies (deep learning, convolutional neural networks, etc.) have the potential to improve the accuracy of occupational disease diagnosis, prediction, and assessment. For example, the convolutional neural network was applied to the diagnosis of pneumoconiosis. It helps to diagnose pneumoconiosis with high speed and high accuracy [140].

The methodology evolution process shows that more and more methods from multiple disciplines are applied in the OHS domain. The enrichment of the methodologies is also consistent with the increasing research topics in this field. Typically, epidemiology has specialized research methods that provide medical evidence to effectively characterize the nature of occupational diseases. However, some of these methods are too time-consuming and difficult to give rapid feedback on the results. As a result, analytical methods may be applied (e.g., meta-analysis, bibliometric analysis, etc.). Evaluation models based on mathematical principles that enable rapid analyses have also developed rapidly in the past two decades. More and more mathematical approaches are used to handle the uncertainty and invisibility problems of the models, and this optimization process will still be explored in the future. At the same time, with the development of computer technology, the application of advanced technologies such as artificial intelligence in the diagnosis, observation, and analysis of occupational diseases is fully foreseeable.

4. Pathways for Future Works

This section investigates research directions that may receive more attention in the next period (2023–2030) on the basis of the current needs and gaps considering the OHS development in China.

4.1. Research on Emerging Occupational Diseases

According to the bibliometric analysis results, the emergence of new occupational diseases (occupational burnout, occupational skin diseases, etc.) became new health threats posed to occupational personnel. The prevention and control of occupational diseases are becoming more difficult because the damages of new and old occupational diseases are increasingly intertwined and superimposed. Common problems such as work stress and musculoskeletal disorders are noteworthy, and infectious diseases such as COVID-19 have brought new challenges to occupational health. However, current laws, regulations, and standards lack legal definitions and prevention and control measures for new occupational diseases, and they can only be treated as work-related diseases. Therefore, while future research will continue to improve the prevention and control of conventional occupational diseases, it may focus on the pathogenesis and hazards of new occupational diseases and promote the improvement of the legal definition and legal catalog of occupational diseases. Additionally, the prevention and control of new occupational diseases is not only a matter of the efforts of the government and research institutions but also requires cooperation with enterprises to conduct research on occupational health and safety management systems that are more industry-specific and practical. For example, the government should cooperate with enterprises to identify the current situation of new occupational diseases among their employees and study and formulate OHS management regulations applicable to enterprises.

4.2. Occupational Health Foundation Construction

Since 2009, occupational health infrastructure has been comprehensively developed as a rigid goal of occupational disease prevention and control, and related articles have continued to be produced due to the implementation of the NODPCP. However, there are few relevant studies on the protection of occupational health rights and interests according to the analysis of the retrieved literature. Additionally, the fact that the practicality was not fully emphasized in previous studies is another barrier to addressing the weak links of the occupational health management foundation. Therefore, future research may use the "National Occupational Disease Prevention and Control Plan (2021–2025)" [141] as a guide and give more attention to the following three research directions: (i) the lack of a better regulatory system for workers' occupational health rights and interests at the present time; (ii) the lack of the implementation of the main responsibility of the enterprises; and (iii) the workplaces of micro-, small-, and medium-sized enterprises associated with a serious overload of hazardous factors and lacking the protection of workers. Then, the feasible research directions are as follows: (i) research on more practical and efficient occupational disease prevention and control technologies, with the main research directions being occupational disease monitoring and assessment, occupational disease engineering protection, and occupational disease diagnosis and treatment methods; (ii) strengthening the construction of infrastructures, technological equipment, and informatization, for example, constructing a standardized information platform for production, developing occupational hygiene management informatization systems, and developing environmental monitoring systems and occupational disease diagnosis technologies with higher accuracy; (iii) further research and improvement of occupational health-related laws and regulations, such as analyzing and determining the priorities of occupational health rights and interests of different genders in light of the gender differences of occupational groups; (iv) investigation by supervisory departments of reasonable human resource allocation methods according to the size of enterprises and strengthening the law's coercive power in implementing the main responsibilities of enterprises.

4.3. Application of Advanced Technologies and New Designs

The diagnosis of occupational diseases (e.g., pneumoconiosis) still largely depends on the experience of doctors, which seriously affects the efficiency of diagnosis [140]. AI technology has gradually matured in the application of the auxiliary diagnosis of occupational diseases, which has greatly improved the efficiency of occupational disease diagnosis. However, the test samples in the current study are dominated by early-stage patients. However, in reality, more patients are usually diagnosed when they have progressed to the middle and late stages. Therefore, more middle- and late-stage subjects with the disease are needed as test samples to enhance the rapid characterization of the model for middle- and late-stage patients. Furthermore, the discriminatory power of such aided diagnostic techniques is not sufficient for different diseases with similar symptoms or foci. This will require significant sample learning as well as technological improvements to be resolved. Computer vision (CV) technology has significant advantages in collecting the visual information of workers, and breakthroughs have also been made in the OHS monitoring based on the CV technology [39]. However, the shortcomings of the CV technology in complex scene understanding and overall monitoring system design limit the application of CV in automated management. In addition, standardized and shared data platforms and validation of data evaluation methods are also currently unresolved issues [39]. Furthermore, the motion capture technology [142,143], visual feedback [144], and other technologies may be combined to develop motion analysis and ergonomics management platforms for workers' monitoring and training [145]. Real-time motion analysis systems are able to provide feedback to operators based on real-time monitoring data for ergonomic assessment in order to correct or improve human movement and behavior. However, there are limitations to the application of these technologies. More complex metrics (e.g., occupational repetitive motions) are temporarily difficult to incorporate into the analysis system, and the tools used to collect postural data need to be updated and adapted (e.g., depth cameras). In addition, the differences between different machine learning algorithms and the mechanical features used for the analysis need to be further discussed with ergonomists.

The importance of PPE (personal protective equipment) for professionals has been demonstrated in many articles. During the COVID-19 pandemic, PPE also plays an important role in epidemic prevention and control. However, due to prolonged wearing of PPE, symptoms of moisture stress and heat stress, as well as other skin problems, seriously affected the physical condition. Thus, research on the optimal design of PPE is strongly demanded, and safer and more comfortable PPE is in urgent need. It means modifying the material of PPE to improve heat dissipation and dehumidification, designing protective masks that fit the face better and are thin and light, etc., while maintaining protection. At the same time, more accessible and practical PPE training and practice programs should be implemented to improve the efficiency of emergency protection training for frontline personnel and to ensure that they can reduce the negative effects of PPE on their bodies through appropriate work–rest cycles.

4.4. Occupational Health and Safety Risk Assessment

The NODPCP also mentions the need to strengthen the construction of technical support systems, one of which is to strengthen the ability of the OHSRA (occupational health and safety risk assessment). The OHSRA plays a key role in preventing and reducing occupational diseases and injuries by providing quantitative or qualitative risk assessments to support decision-making with respect to protection strategies. The OHSRA methods usually include an exposure assessment and model assessment. Exposure assessment is usually used to measure the concentration of harmful substances in the workplace or to check the abnormal degree of human body indicators to assess its physiological hazards to the occupational population. Model assessment aims to establish an assessment model to clarify the risk and its characteristics in the workplace. Exposure assessments need to quantify occupational hazards intuitively and unambiguously, while model assessments need to address the uncertainty and subjectivity in the modeling process. Although the application of many methods (Delphi method [146], fuzzy theory [139], Bayesian network [147], etc.) has effectively reduced the impact of uncertainty and subjectivity on the risk assessment results, the handling of uncertainty and subjectivity still needs to be improved. Hopefully, the implementation of data-driven approaches helps to reduce the uncertainty and subjectivity in risk assessment [148]. Moreover, empirical studies of model assessment are difficult and can be effectively overcome by techniques such as neural networks. Exposure assessment reflects the work environment hazards to occupational populations, and the biomarker exposure evaluation method is one of the most effective assessment methods currently available [149]. However, the inability of this method to characterize long-term chronic health effects, as well as its disadvantages in terms of cost and experimental conditions, necessitates the search for more advantageous methods. The development of real-time, multitype, and multiscale exposure measurement techniques with high spatial and temporal resolution for individuals and populations in combination with GPRS (General Packet Radio Service), GIS (Geographic Information System), and GPS (Global Positioning System) is a viable option. Biomarker profile characterization based on single or multiple pollutant biomarkers can balance the disadvantages of biomarker exposure assessment. Additionally, MSDS is a major cause of disability in China [150], which should be given attention in the occupational health risk assessment. New methods or models for ergonomic risk assessment may be developed based on human movement/posture monitoring technologies. Rehabilitation techniques based on risk assessment may be developed and integrated into health care services. The ergonomic risk assessment can be used as an effective tool for working equipment/tool design. Meanwhile, the development of ergonomic risk assessment models helps to conduct ergonomic posture correction and training, which can reduce the risk of deterioration or complications of musculoskeletal disorders at an early stage.

5. Conclusions

This study conducts a systematic analysis of the research related to the OHS in China. The main conclusions are as follows. The annual publication volume of journal articles shows a fluctuating growth trend year by year, which is related to actual events. CJEOM is the journal with the most published related articles. The CCDC is the most prolific institution in China. In terms of domestic cooperation, Taiwan has the most cooperation with the mainland. Xia Z L is China's most prolific scholar in terms of OHS-related research. Regarding international cooperation, China has the most cooperation with the United States. NCI (USA) is the institution with the most cooperation with China. Utrecht University (The Netherlands) is a non-US institution with the most cooperation with China. Prof. Christiani DC (Harvard) is the most frequent international scholar who collaborates with Chinese scholars on OHS-related topics.

This study investigates the main research topics of the OHS in China, and also examines the research topic evolution and research method evolution processes. It shows that the research topics of the OHS in China are diverse. The research topics include, but are not limited to, disease prevention, psychological safety, occupational exposure, and health risks. Before 2001, occupational exposure, smoking, and benzene were the mainstream of the research. Since then, occupational exposure has been the focus of each time period. From 2001 to 2008, lung cancer research dominated occupational exposure-related cancers, and SARS-related research was also a hotspot during this period. Psychological health of the occupational population began to receive attention from this time period. From 2009 to 2018, two NODPCPs (National Occupational Disease Prevention and Control Plan) were successively promulgated to promote the progress of OHS research. The OHS management has become a research hotspot, and occupational/job stress has become a key research topic for occupational psychological health. From this period, research on MSDS and human factors also began to increase. From 2019 to 2022, COVID-19 has become a hot research topic. Occupational stress/burnout was recognized by WHO as an occupational disease, and related topics have received more attention. It can be clearly seen that the key research topics have evolved from physical health to psychological health, and psychological health and OHS management have received more extensive attention. In terms of research methods, epidemiological methods have always been the widely used conventional method, and questionnaires are a commonly used method to obtain research data. Risk assessment models have also shifted from single-method models to integrated models, reinforcing the objectivity, capability, and accuracy of the models. AI technology has gradually been applied in this field, which has greatly promoted the innovation and capability of traditional methods. In short, with the research methods from different disciplines being combined and integrated, the characteristics of multidisciplinary intersections are becoming more and more obvious in terms of OHS-related research.

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Based on the identification of current research needs/gaps, pathways for future works are also suggested by this study. Several research directions may be focused to boost the OHS development in China. (i) While preventing and controlling conventional occupational diseases continuously, the prevention and control of emerging occupational diseases and the development of corresponding legal protection systems for patients with new occupational diseases should be stressed. (ii) Additionally, the construction and enhancement of occupational health foundations are important, particularly, considering the protection of workers' occupational health rights and interests. (iii) The development and implementation of advanced technologies and new designs (such as AI technology and computer vision technology) in the OHS domain are necessary. For instance, assisted diagnostic techniques based on machine learning, the research on high-performance PPE, and the applications of motion capture technologies and ergonomics management platforms for workers' movement monitoring and training. (iv) Occupational health and safety risk assessment plays a key role in preventing and reducing occupational diseases and injuries by providing quantitative or qualitative risk assessments to support decision-making with respect to protection strategies. The improvement of the occupational health and safety risk assessment models and the integration of the risk assessment models into the health care services are also of significant importance.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su151914061/s1, Figure S1: Collaboration network of domestic institutions on occupational health and safety in China (Institutions with more than 23 publications); Figure S2: Scholar collaboration network on occupational health and safety in China (Authors with more than 14 publications); Figure S3: Top 10 most cooperative countries on occupational health and safety in China; Table S1: Top 15 most prolific Chinese institutions on occupational health and safety in China (TP > 90); Table S2: Top 10 prolific Chinese scholars and their research interests; Table S3: Top 10 active foreign institutions on occupational health and safety in China; Table S4: Top 5 prolific foreign scholars and their research interests.

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