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The Whole Nine Yards of Safety Climate Research

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Abstract: The idea of safety climate is known for its complexity, as the notion of safety climate itself is perplexing through its content, dimensions, and application in different disciplines. The prime motive of this research is to apply bibliometric analysis to the safety climate research construct, ascertain the pivotal influences and elaborate a structure, characteristics and progresses made for the last 16 years. Application of this statistical technique for safety climate research construct is essential to understand the overall research patterns, as no such analysis can be found to date addressing the vast amount of data that we have utilized. In doing so, a total of 2,027 publications from 2005 to 2021 on safety climate were identified through the Web of Science. These 2,027 publications cover 5,723 authors, 686 research journals, 90 countries or territories, and 2,092 organizations and institutions. The main research areas associated with safety climate were healthcare, patient safety climate, psychological climate, and organizational safety climate. Contemporarily, food safety climate and food safety culture are also associated with safety climate. Historical application of safety climate in high-reliable industries provides a rationale to be utilized in other occupational settings. Prominent journals, publications, and authors from the last decade are also identified. Geographically, the USA, Australia, UK, and Canada are the most contributing countries for safety climate research. More collaboration on safety climate research is needed. Presently concentration in this research domain is found in certain countries, which creates geographical inequality in the publication in the purview of safety.

Keywords: bibliometric analysis, safety climate, organizational safety climate, safety performance, safety culture, health-care.

全九码安全气候研究

摘要：安全气氛的概念以其复杂性而著称，因为安全气氛的概念本身因其内容、维度和在不同学科中的应用而令人困惑。本研究的主要动机是将文献计量分析应用于安全气候研究结构，确定关键影响并阐述过去 16 年的结构、特点和进展。将这种统计技术应用于安全气候研究结构对于理解整体研究模式至关重要，因为迄今为止还没有找到解决我们所使用的大量数据的此类分析。在此过程中，通过 科学网确定了 2005 年至 2021 年间关于安全气候的总共 2,027 篇出版物。这 2,027 篇出版物涵盖 5,723 位作者、686 种研究期刊、90 个国家或地区以及 2,092 个组织和机构。与安全氛围相关的主要研究领域是医疗保健、患者安全氛围、心理氛围和组织安全氛围。同时，食品安全氛围和食品安全文化也与安全氛围相关。安全气候在高可靠性行业的历史应用提供了在其他职业环境中使用的基本原理。还确定了过去十年的著名期刊、出版物和作者。从地理上

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看，美国、澳大利亚、英国和加拿大是安全气候研究贡献最大的国家。需要在安全气候研究方面开展更多合作。目前该研究领域集中在某些国家，这在安全范围内造成出版物的地域不平等。

关键词：文献计量分析、安全氛围、组织安全氛围、安全绩效、安全文化、医疗保健。

1. Introduction

The availability of information plethora and never-ending research publications on any research topic or domain makes it difficult for scholars and researchers to evaluate its contemporary understanding, utility, and future direction [1], [2]. To overcome this issue of "excessive information availability" and wide scope of different research domains, certain techniques help researchers and scholars grasp the greater or even microscopic image of the overall progress and current state, e.g., Bibliometric Analysis. Mapping any research can be done through this technique to see its quantitative facts related to its publication history, prominent authors/institutions, characteristics, associated fields, and the overall progress made [3], [4]. This technique also helps researchers by providing research outlines, past and present paradigms, outstanding works, prominent research bodies, the geographical distribution of research, associated key terms, and most importantly, the association between authors and their research cooperation [5].

This technique is also useful and relevant for new/upcoming researchers who are yet to choose their research domain. Using this analysis, they can explore key researchers, the notable past works, institutions, and journals working on their interested research domain and present research and emerging themes. This technique will make it easier to identify research gaps and explore new avenues for leading subjects and research directions [6]. It will be feasible and more helpful for researchers to use the bibliometric analysis technique if they are interested in securing research grants by utilizing the ascertained statistics. Bibliometric analysis technique has been utilized in this research paper to the field of “safety climate”, a much-explored safety-related concept that is widely used to enhance safety performance and its behavioral aspects [7], [8]. The concept of safety climate was discussed in [9], which describes safety climate as the “shared set of cognition (held by workers and employee) concerning the organizational safety aspect”. This definition specifies safety climate as an individual’s own experience of safety throughout their working environment. From this onward, increased attention toward safety climate has been witnessed. Despite the improvement made in safety research, incidents still occur at domestic, commercial, and industrial levels with ever-rising trends. As stated by International Labor Organization (ILO), around 340 million (only reported) occupational incidents took place, causing 6,000 deaths every year [10]. Generally, research plethora on a safety culture and safety climate was initiated immediately after the historical and most prominent safety lapses, i.e., Chernobyl and Bhopal causing catastrophic consequences for human beings.

There is a diversified school of thought on the interpretation and meaning of safety climate, its unit of analysis, and causal model in organizational safety and its success [11], [12]. According to [12], safety climate is a collective phenomenon comprised of the collective perception of organizational processes, procedures, certain practices, and acts appraised by organizations for larger goals. Pertinently, safety climate becomes more complex, and additional difficulty is added with safety culture (another safety construct). Thus, the ambiguity between safety climate and safety culture persists [14]. Firstly, safety climate is a complex research topic that has multidimensionality (inclusion of 50 different variables in safety climate questionnaire) and multilevel (organizational safety climate, Team and unit-level safety climate, industry level, and national level) aspects associated with it, making it more difficult to comprehend and specify [15].

Moreover, there is a minimal consensus about measuring safety climate, i.e., how to measure this phenomenon on the universal level or relate this to a specific industry [16]. Whereas, according to [17], there is no consensus on the operationalization and conceptualization of safety climate construct, and some of the related dimensions are irrelevant to safety climate. Secondly, safety climate is a multi-domain research topic applied to diverse industrial and service sectors like chemical processing, construction, hospital, healthcare, hospitality, restaurant, accommodations, manufacturing, maritime, mining, nuclear, offshore, and gas production and transportation [15]. Such widespread application of safety climate in different industrial and services contexts, its multidimensionality in nature, and inconsistencies in the previous finding [18] pushed us to conduct bibliometric analysis to observe the mesoscopic view of the safety climate research. By doing so, we aim to observe its current standing, association with other related research domains/constructs, and forthcoming

avenues. This descriptive paper is intended to provide readers with a mesoscopic view of the key characteristics of safety climate research works through bibliometric analysis. Results from this analysis would provide a vivid image of the research progress made so far for the safety climate. It will be beneficial for researchers to identify influencing authors, publications, publication bodies, institutions, cited references, and new research matters for future inquiry.

2. Data and Method

Web of Science was utilized (www.webofknowledge.com) to collect the relevant data; it is one of the leading data sources for its acknowledgment in scientific publications for various research domains. The Web of Science database is updated frequently, and many researchers in different domains use it. Whereas, if this website is used later, specifically for safety climate, it is most likely to yield a different number of published works because of the continuous database changes [19], [20]. To ascertain published works on safety climate, the term "safety climate" was written with the inverted commas in the search bar to specify the search results. Through this method, Web of science produces results by looking into the Title, Abstract, Keywords, and Author keywords of relevant published works, thus making the outcome more reliable and robust [19]. The period was selected from 2005 to 2021 in a web of science's core database to access the complete information and record of published works, and the same can be found in Figure 1.

Through the Web of Science core database, 2,027 published works were identified mentioning safety climate, all of which were considered to be included in the analysis. Out of 2,027 published works, n = 1751 were Research Articles, n = 141 were Proceedings papers, n=106 were review papers, and the rest were book chapters, editorial materials, letters, and news items. Figure.02 shows the overall distribution of identified published works found through the Web of Science portal.

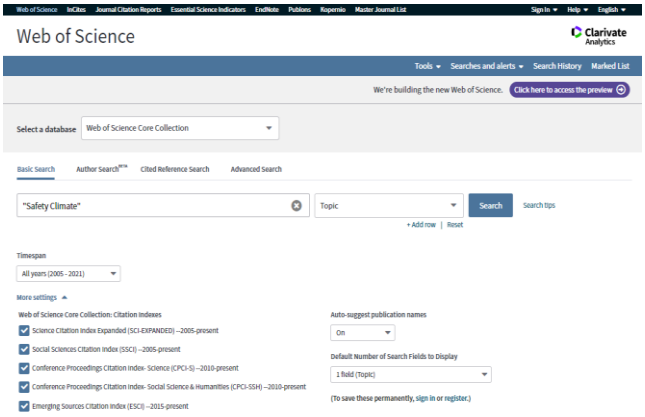

Fig. 1 Web of Science snapshot for data search

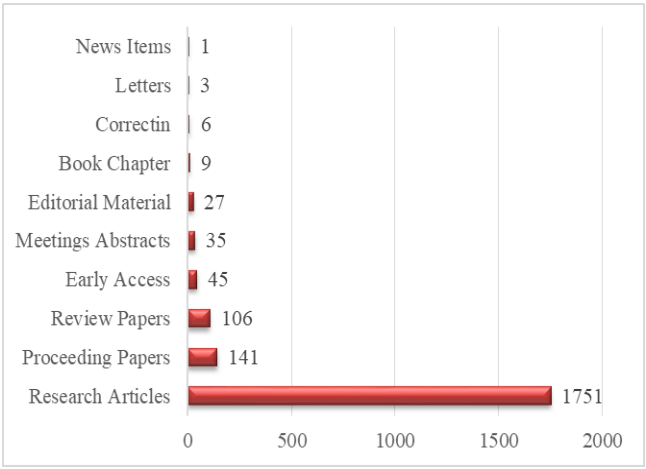

Fig. 2 Distribution of identified published works through the Web of Science

Through this research database, exhaustive information about the time of publication, contributing authors, research title, abstracts, publishing body, and pertinent research domain, along with cited references, can be extracted. To analyze the downloaded data of 2,027 published work from the Web of Science, software like Microsoft Excel, Word, and PowerPoint were used. VOSviewer, the freely available software available at https://www.vosviewer.com, was utilized to analyze the visual aspect of the data (pivotal element of the analysis) [21]. All in all, the software mentioned above was used to unravel the following aspects of safety climate research; what are the publication trends and research growth on safety climate research? Who are the outstanding authors associated with safety climate research? What are the main publishing bodies publishing on safety climate research? What is the state of cooperation between authors working on safety climate research? What is the state of global/geographical and organizational

distribution of safety climate research? What is the citation and co-citation pattern for safety climate research? What are the prominent key terms associated with safety climate research? Moreover, lastly, what are the major subject categories associated with safety climate research.

To address the above research aspects, VOSviewer uses a mapping technique that relates the research topic through the two-dimensional map to assess its link and association with identical research topics/areas and provides the maximum possible accurate results. Another technique that VOSviewer applied is cluster formation, which distinguishes different research clusters having discrete colors [21]. As we are using VOSviewer to see the visual results, the following understanding is must: (1) number of publications and its occurrence is reflected through the size of circle, (2) color of the cluster shows its distinctiveness from others, (3) similarity and coherence of different cluster is exhibited through the distance between circles [22], [23]. In the following paras, in-depth analysis and discussion will be done to provide easy comprehension

3. Results and Discussion

3.1. Publication and Output Growth Trend

One of the advantageous ways to see the trends in scientific research and its discipline is finding the number of peer-reviewed publications throughout the period. It is evident to see the increasing trend of publication on safety climate in Fig. 3. There were merely 28 publications found in 2005 as per the Web of Science database. Until 2009, publications on safety climate were restricted to few numbers (less than 100), as shown in Fig. 2. From 2010 onwards increase in the number of publications can be observed. A maximum number of publications observed in 2020 (n=245) is a good sign, and in the future, a much increase is expected. Initial slow growth in the publications of Safety climate is questionable and is not easy to explain. One of the possible explanations for a low number of publications could be the understanding of this variable, its nature, or its prior association with industries and occupations.

Price's law enables us to understand these different phases of the research to explain the growth, decline, and maturity of scientific publications [24]. As stated by this law, the progress of the research domain can be elaborated in four different phases, (1) a pioneering phase, in which a group of the researcher(s) or individual initiates to publish on certainly new field, (2) exponential growth phase, where the concentration of researchers to work upon such ideas grows to a higher number to explore more aspects of the subject, (3) consolidation, where learning is enforced, and practicality is observed, (4) decline in the interest of field by researchers, where saturation on any field is achieved [25].

Relatively, safety climate is a well-researched concept, and its application in diverse occupational settings is evident [2], [26]–[29]. Just by looking at the trends in the yearly publication in Fig. 2, it can be established that the significance of safety climate for safety research is on an increasing trend, but from the year 2017, increase in the publication is inconsistent, and there is no remarkable or marginal change observed in every coming year. It may be possible that research on safety climate is going through its third phase of growth, i.e., consolidation, where safety climate is tested and applied in different settings and verified results. Initially, for safety climate, the % growth of publication was about 33% annually, which has now been declined to almost 4%, reflecting its movement toward its fourth stage. At this stage, Meta-studies are conducted to observe the cohesiveness and consistencies in the findings and form a larger image to understand the phenomenon. Keeping in view the aforesaid, it can be stated that the amount of work carried out on safety climate is reaching towards its fourth phase, i.e., saturation, which needs immediate attention of the research community to see how this construct can be utilized further.

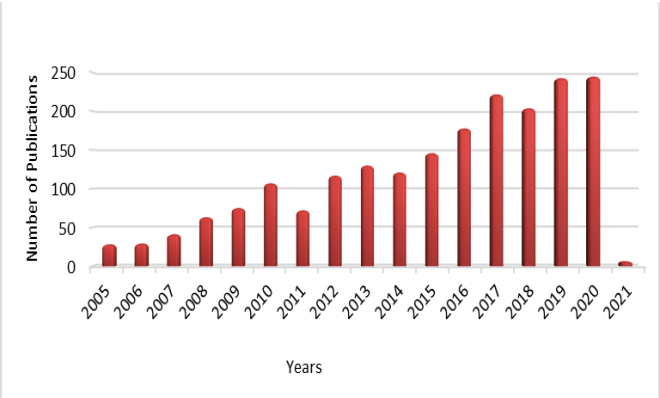

Fig. 3 Publication growth of safety climate research

3.2. Authors and Their Cooperation

In any field of science, the impact of scholarly work, qualitative or quantitative, is measured or gauged through its citation and acknowledgment by other authors. For safety climate, a total of 2,027 publications were included in this study through the Web of Science core database. Those 2,027 publications were written by 5,723 different authors. Out of all publications, it was noticed that the maximum number of authors, 68.85% (n = 3940/5723), were cited in at least one publication on safety climate. Whereas 16% (n = 922/5723) of the studies could not secure citation, which is significant in number. To elaborate further, 8.25% (n = 472/5723) of authors were cited in between 50-100 times, 3.70% (n = 212/5723) of authors were cited in between 101 to 199 times, 1.5% (n = 88/5723) authors were cited in between

201 to 299 times, 0.91% (n = 52/5723) authors were cited between 300 to 499 times, 0.24% (n = 14/5723) authors were cited in between 500 to 699 times and 0.24% (n = 14/5723) authors were cited between 700 to 100 times. Lastly, only a handful of authors, i.e., 0.16% (n=9/5723), were cited more than 1000+ times, and the same is depicted in Fig. 4.

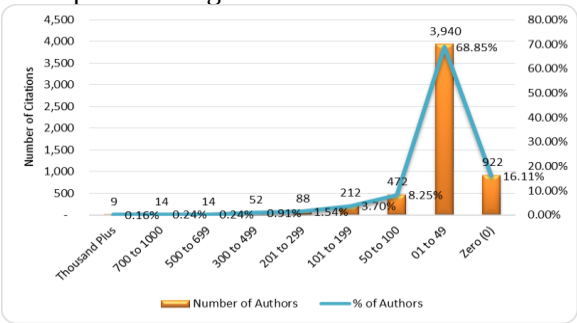

Fig. 4 Distribution of citations concerning their percentage

It can be observed through this analysis that there is an apparent saturation of citation associated with a small group of authors and individual researchers whose work was more productive or influential in the field of safety climate, which is in harmony with other research fields [30]. The most influential authors are shown in Table 1, in which the ranking is made according to the number of publications held by authors irrespective of their authorship order. Amongst all, Maureen F. Dollard stands tall, being the most productive author on safety climate with (n=34) publications, followed by Yueng-Hsiang (n=30) publications, Thomas A. Arcury and Sara A. Quandt (n=23) publications, Jin Lee (n=19), Dov Zohar (n=18), and lastly Morten Birkeland Nielsen and Gil Luria having (n=17) publications. From the analysis, we also observed some disparities in the average number of citations per publication (ranging from 21 to 114) and the number of publications as first author (ranging from 01 to 15), which shows the concentration of authorship to few authors only.

Table 1 Top of the most productive authors publishing on safety climate

Author's name	**Number of publications on safety climate as per Web of Science**	**Number of citations as per Web of Science**	**Average citations per publication for safety climate**
Maureen F. Dollard (Australia)	34	1216	35.76
(Yueng-hsiang) Huang (USA)	30	771	25.7
Thomas A. Arcury (USA)	23	397	17.26
Sara A. Quandt (USA)	23	397	17.26
Jin Lee (USA)	19	400	21.05
Dov Zohar (Israel)	18	2066	114.78
Morten Birkeland Nielsen (Norway)	17	364	21.41
Gil Luria (Israel)	17	1000	58.82

Further analysis suggested that, on average, 1.4 authors worked upon individual publications, which shows that more collaboration is needed to increase global outreach of safety climate research. Out of all 2,027 publications, 5.9% (n = 119/2,027) had a single author, 17.9% (n = 362/2,027) had two authors, 24.6% (n = 499/2,027) had three authors, 19.9% (n = 403/2,027) had four authors, 13.4% (n=271/2,027) had five authors, 7.7% (n = 156/2,027) had six authors and 10.7% (n = 217/2,027) had more than seven authors. From the analysis above, it can be justified that there is a moderate amount of collaborative research for safety climate, as 94.1% (n = 1908/2,027) of the selected papers have multiple authors (more than one). This amount of cooperation on safety climate research between authors shows room for improvement for authors globally. This opportunity can be utilized to globalize this research phenomenon on a much wider scale, and it can provide better collaboration opportunities in the future [6].

3.3. The Cooperation Pattern

Co-authorship of authors publishing their work on safety climate was analyzed with VOSviewer software. Among the numerous publications, authors were chosen for the network analysis who have published at least five researches on safety climate. The finding of the authors' cooperation network can be seen in Fig. 5 where the size of the circle shows the magnitude or amount of publication held by a single author and the lines between author exhibits the existence of co-authorship and cooperation. Different colors show the distinct cooperation cluster, where researchers are relatively working on the same or homogenous ideas. Three different colors of clusters can be observed in Fig. 5.

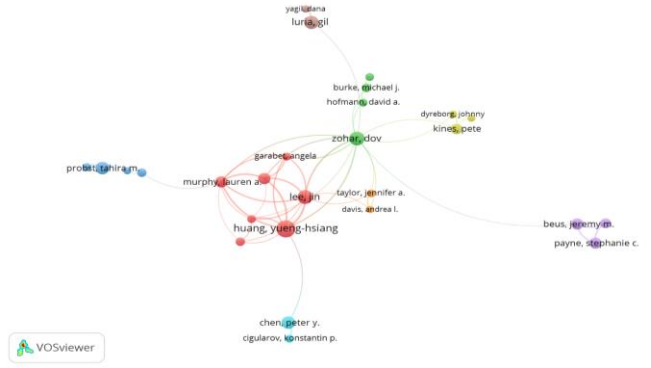

Fig. 5 Authors' cooperation network on safety climate research

Moreover, in this network, prominent authors like Yueng-Hsiang Huang, Dov Zohar, Lauren A Murphy, and Jin Lee have outstanding research networks within and outside their cluster. It is worth noticing here that, although few researchers have produced a substantial amount of work on safety climate, they are still not visible in the cooperation network. It may be because they are working a lot in the same research cluster and circles close to them, thus limiting the potential usability and utility of the safety climate phenomenon. Aforesaid in view, research cooperation needs to be further enhanced.

3.4. Journals Publishing on Safety Climate

From the analysis, it was found that 2,027 publications were published in 686 different journals. This diversity in publication bodies depicts the variability and the presence of multidisciplinary application of safety climate construct. Of the 686 journals, 431 journals (63%) published only one manuscript, whereas Safety Science is the only journal publishing most on safety climate, i.e., 187 (09%) articles in total. Figure 6 depicts the prominent journals publishing on safety climate, which shows variation in the publishing bodies ranging from pure management-related journals to some scientific journals. This may be a good sign for researchers, as Safety Science Journal can be helpful for them in finding most of the prominent researchers over a single platform. Moreover, a strong network of researchers and possible collaborators can also be identified through these results for future researchers after seeing the prominent journals working on safety climate.

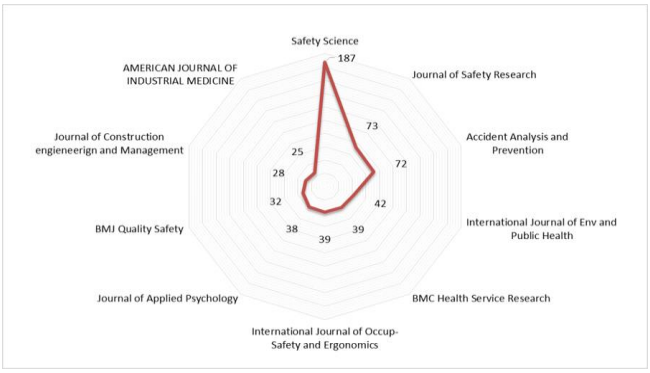

Fig. 6 Prominent journals publishing on safety climate

3.5. Countries and Territories Publishing on Safety Climate

Safety climate research was carried out in 90 different countries. Out of 90 countries, 43 are located in Europe, 04 in North America, 23 in Asia, 02 in Oceana, 06 in South America, and 12 in African. Out of all countries, the United States of America (USA) is the only country that produced about 36% of the research with the contribution in 746 publications irrespective of the authorship priority. The second-largest contributor country is Australia from Oceania, having 253 publications, whereas the third and fourth largest contributing countries are the People's Republic of China with 180 publications and the United Kingdom with 137 Publications. If we look at the continental contribution perspective, Europe is the most dominating continent with over 870 publications on safety climate, followed by Asia, North America with 850 publications, Asia with 578 publications, Oceania with 274 Publications, South America with 53 publications, and Africa with 35 publications. Contribution at the individual level, i.e., country-wise, can be seen in Fig. 7 for ease of understanding. The global overview of the contribution by each country can be seen in Fig. 8.

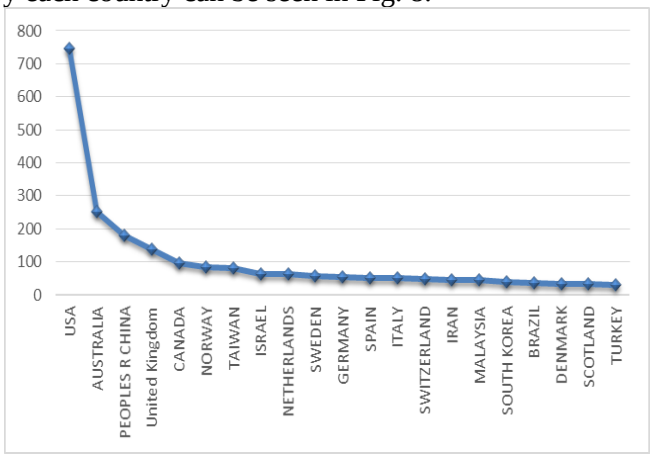

Fig. 7 Prominent journals publishing on safety climate

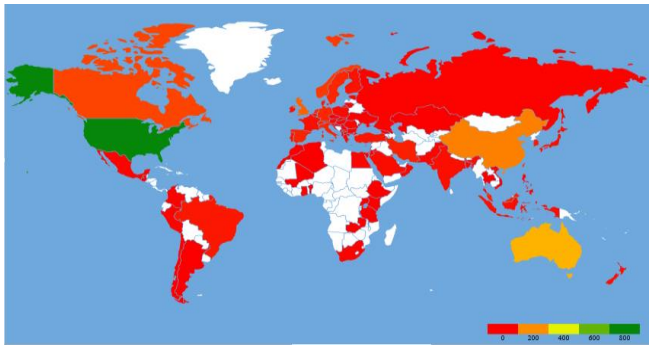

Fig. 8 The number of publications contributed by countries (irrespective of authorship ranking)

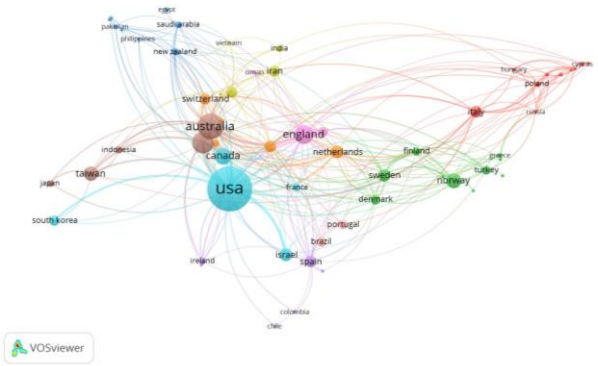

Fig. 9 Global cooperation network on safety climate

It can be very firmly established from the above figures that those more economically developed countries seem to have more scientific and academic studies. In our case, America, Australia, China, United Kingdom, Canada, and some European countries who are also a member of G-7 group, can be seen contributing clearly towards the safety climate research domain. The domination of developed countries publishing on safety climate shows the relatedness between higher scientific and academic activities and publication output which also place these countries at the forefront of the research field. By looking at the total contributions made by each continent in Fig. 8, a general inequality can be observed, which shows the need for safe climate research to be conducted in other countries and continents as well, as its association with certain parts of the globe may limit the usability and reliability of the research domain.

Another aspect for the usability and generalizability of the research domain is the collaboration between different authors, i.e., co-authorship in between different countries. VOSviewer was used to analyze the cooperation network, specifically for safety climate, to cater to this aspect. Countries having a minimum of five publications were added to the analysis to see the maximum possible collaboration. Through VOSviewer, territories not connected with other countries in the cooperation network can be excluded to see the most active cooperation network. The result of the analysis is depicted in Fig. 9. The amount of published work is represented through the size of the circle, and the cooperation's network strength/magnitude is reflected via the thickness of the link.

From the above, three main clusters among USA (blue), Australia (brown), and England (Pink) can be observed, with other small and distinct colored clusters. The same color represents the research cluster having the associated nature of research. In harmony with other research domains, countries involved in collaborative research are more geographically correlated. They hold the position centered around the most productive countries in the purview of publication output [31]. The above figure provides an optimistic view for future researchers to initiate further global collaborations and utilize the potentials of safety climate to see the future value and usability of safety climate construct.

3.6. Organizations Publishing on Safety Climate

According to the data derived from Web of Science, 2,027 publications were produced by 2,092 different research organizations and institutions. However, in such publications, one author can be associated with more than one institution, or the manuscript can be made with the conglomerated efforts of different authors from different institutions. To be precise, 65% of organizations (n = 1359) only participated in single publication, 14.8% (n = 310) contributed in 2 publications, 6.3% (n = 132) contributed in 3 Publications and 3.6% (n = 75) participated in four publications. Rest 10.3% of institutions participated in publications ranging from 5-46. Table 2 provides a brief picture of prominent institutions published on safety climate, and in that, USA is the leading country with most institutions working on the same. Further analysis revealed that out of 2,027 publications, 989 were funded by different organizations ranging from government departments to universities and private organizations (i.e., industry and health care), which again shows the utility and versatility of safety climate for different types of industries. The squared and justified application of safety climate research in other

fields can provide more sound results for both industry and academia.

Table 2 Top universities publishing on safety climate

No	Organization Name	Country	Number of Publications
1	Harvard University	USA	44
2	University of Bergen	Norway	40
3	Queensland University of Technology	Australia	35
4	Liberty Mutual Research Institute for Safety	USA	32
5	Technion – Israel Institute of Technology	Israel	29
6	University of Haifa	Israel	28
7	University of South Australia	Australia	28
8	Duke University	USA	27
9	The Hong Kong Polytechnic University	Hong Kong	27
10	Johns Hopkins University	USA	24

3.7. Citation Analysis

Citation is the process through which knowledge inflow and outflow can be measured against a specific domain or any published scholarly work in science. It consists of two main behavioral inputs, i.e., the amount of reference being used by researchers in particular research, also called 'citing analysis', and the output of knowledge, i.e., acknowledgment or publication by other authors, i.e. (manuscript is used as a reference in other publication as reference), known as 'cited analysis' [32]. First, we will be addressing the aspect of cited analysis for safety climate research.

Web of Science was used to ascertain the data for citation analysis. All in all, 2,027 publications of safety climate attained 47,423 citations with the average of 23 citations (n = 47423/2,027) per document. It was notable to see that 16.5% (n = 334/2,027) publications got 0 citation (at the time of data extraction) which is a notable portion of total 2,027 publications. To see the in-depth picture of the situation, is was realized that 8.6% (n = 174/2,027) of the publications secured at least one citation, 34% (n = 6889/2,027) got 2-10 citations, 36.5% (n = 739/2,027) got 11-100 citation, 3% (n = 60/2,027) got 101-200 citations, 1.1% (n = 22/2,027) got 201-400 citations, 0.24% (n = 4/2,027) got 401-600 citations and finally 0.24% (n = 5/2,027) got 601-810 Citations. Some of the highly cited work on safety climate can be seen in Table 3 for better understanding.

Pertinent to this, few authors like [33], [34] stated that the amount of citation a certain publication shows its influence irrespective of its reputation. In harmony with this, some researchers [35], [36] are of the view that the quality and content of published work can't be measured through its citation score, as it is not the right measure to see the quality aspect of the publications, but its visibility only. Another way to increase the citation of the manuscript is to publish in open access journals to have more audience accessing the published work.

Table 3 Frequently cited publications on safety climate

Title & Year	Authors	Source Title	Total Citations
The Safety Attitudes Questionnaire: psychometric properties, benchmarking data, and emerging research 2006	Sexton, J.B.; Helmreich, R.L.; Neilands, T.B.; Rowan, K.; Vella, K.; Boyden, J.; Roberts):R.; Thomas, E.J.	BMC Health Services Research	807
Workplace Safety: A Meta-Analysis of the Roles of Person and Situation Factors 2009	Christian, M.S.; Bradley, J. C.; Wallace, J. C.; Burke, M. J.	Journal of Applied Psychology	669
A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels 2006	Neal, A.; Griffin, M.A.	Journal of Applied Psychology	656
A multilevel model of safety climate: Cross-level relationships between an organization and group-level climates 2005	Zohar, D; Luria, G.	Journal of Applied Psychology	655
Safety at Work: A Meta-Analytic Investigation of the Link Between Job Demands, Job Resources, Burnout, Engagement, and Safety Outcomes 2011	Nahrgang, J. D.; Morgeson, F.P.; Hofmann, D.A.	Journal of Applied Psychology	607
Employee attributions of the why of HR practices: Their effects on employee attitudes and behaviors, and customer satisfaction 2008	Nishii, L. H.; Lepak, D. P.; Schneider, B.	Personnel Psychology	590

Organizational Climate and Culture 2013	Schneider, B.; Ehrhart, M. G.; Macey, W.H.	Annual Review of Psychology, Vol 64	489
Thirty years of safety climate research: Reflections and future directions 2010	Zohar, D.	Accident Analysis and Prevention	475
High-performance work systems and occupational safety 2005	Zacharatos, A; Barling, J; Iverson, RD	Journal of Applied Psychology	441
The relationship between safety climate and safety performance: A meta-analytic review 2006	Clarke, Sh.	Journal of Occupational Health Psychology	436

From the above table, it is evident that most citations were secured by [37]. This paper has been cited 807 times with the average annual citation of 50.4 (n=807/16 years), making this paper the most cited paper on safety climate annually. Overall citation analysis conducted by VOSviewer can also be seen in Figure 10, in which the size of the circle shows the amount of citation attained by the author, and the line shows the relation between other related publications. It can also be observed through Table 3 that the most cited authors are from the USA, which also gives the leader of the first author. Mainly, health care and occupational safety journals are publishing on safety climate. It is also important to see the relationship between the time passed for a certain publication and its citation score. It is obvious to have more citations for earlier published work.

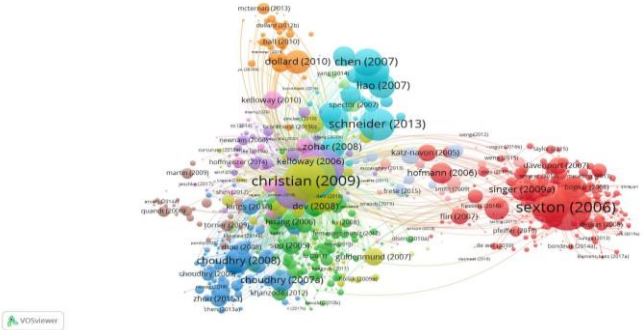

Fig. 10 Analysis of safety climate citations

3.8. Citing and Co-Citation Analysis

We can get the number of comprehensive references used in 2,027 publications on safety climate through the citing analysis. In total, 53,959 references were used by 2,027 published works on safety climate. The most utilized reference was also ascertained via the same analysis technique. It was found that Dr. Dov Zohar is the only author [9], [14], [38]–[42], whose work has been cited as a reference about 2,584 times for his nineteen research works, which is phenomenal and shows its prominence and usefulness for safety climate research. His work on safety climate is found to be the foundation of many kinds of research afterward. Followed by this, researchers like [43]–[45] got cited for their work at about 322, 348, and 320 times in other researches.

Interestingly, 99.752% (n = 53,825/53,959) of the studies were used as a reference less than 50 times, which is a huge chunk of the overall publications. Further, 0.169% (n = 91/53,959) studies were cited as reference in between 51-100 times, 0.057% (n = 31/53,959) studies were cited as reference in between 101-200 times, 0.007% (n = 4/53,959) studies were cited as reference in between 201-300 times, 0.013% (n = 7/53,959) studies were cited as reference in between 301-400 times and only one study was cited for more than 500 time, i.e., 0.002% (n = 1/53,959). We can identify the relationship and interaction between different publications through citing analysis, and a holistic view of the citing behavior of authors can be apprehended. According to [32], the magnitude of citing between two publications reflects their similarity and association. We applied VOSviewer to prepare the co-citation map and its analysis. The criteria for inclusion of publication in the co-citation analysis was the minimum occurrence of unique reference for at least 20 times in all 2,027 publications. Out of all 53,959 unique references, 446 references met this criterion. The results of the co-citation analysis are shown in Fig. 11.

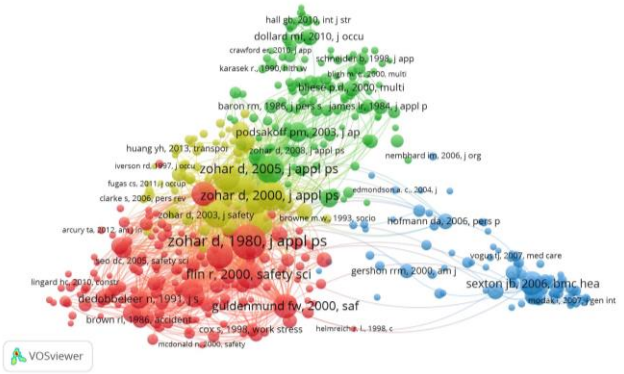

Fig. 11 Co-citation analysis of safety climate

Pertinent to Fig. 11 representing the co-citation analysis of safety climate research, there are circles associated with a total of 2,027 works on safety climate.

To elaborate, Fig. 11 has three main aspects to look at, i.e., (1) size, (2) distance from other circles, and (3) color of the circles. Bigger circles show more citations of that work in safety climate, and the contrary is the case with smaller circles. Another aspect is the distance between circles, which represent the relationship or similarity of the work. The more the circles are distant, the more the possibility of difference persists, and in contrary to this, minimum distance shows the relationship of the study. The color of circles represents the similarity of the research topic. Through the output of co-citation analysis, we can see the emergence of five distinct clusters of safety climate research amalgamated together; (1) Red cluster at the left lower side and (2) Green at the top left (3) Blue cluster at the right side and (4) Yellow at the center of fig.11.

Based on the assessment of individual publications and their titles in five clusters, each cluster can be allotted a different label. Firstly, the Red cluster is distinguished from the rest; it mainly deals with the behavioral and psychological aspects of safety in the purview of safety climate. Some of the theoretical aspects and viewpoints are also discussed in this cluster. Additionally, the Red cluster also houses some foundational works, i.e., establishing the psychological safety climate measurement scale, which are bases for other studies through quantitative analysis through different techniques, e.g., structural equation modeling, regression, and covariance analysis. Secondly, the Green cluster, which mainly deals with rule-oriented facets, organization-oriented and psychological aspects concerning safety behavior and performance, and safety climate measures, is tested in different occupational settings in this cluster. Thirdly, the Blue cluster is entirely distinct from the rest of the clusters. It mainly deals with healthcare occupational settings, where safety climate was associated or tested with patient care, reduced medication errors, staff burnouts, and overall safety performance improvements.

Some of the High-reliability Organizations (HRO) principles and characters are also associated with safety climate in this sector, as the Healthcare sector is mainly counted under the HRO sector. Lastly, the Yellow cluster differs from others as this cluster houses studies that mainly look at the safety climate through a qualitative perspective. A meta-analysis of safety climate research and its association with contextual variables like organizational commitment, leadership role, safety leadership, and occupational stress are mainly associated with safety climate. This cluster of references can be helpful for those who are interested to see the qualitative paradigm of safety climate research to comprehend its past trends and future directions better.

3.9. Research Domain and Categories for Safety Climate

Web of Science possesses at least one subject category of each publication from the first date. The Web of Science core database comprises 250+ subject categories to accommodate each research. This information is usually provided through publishing journals. In total, 25 different subject categories and domains were found associated with 28 publications at the time of research, which shows the variability and versatility of Safety climate research. Out of 25 categories, some were neglected based upon the repetition of published work in the same category, and finally, 04 categories were included with uniquely published work. Out of 04 categories, 04 categories were Engineering, Health, Psychology, and Business Management. To elaborate further, Engineering domain contains 29% (n = 587/2,027) publications, Health domain contains 37% (n=749/2,027) publications, Psychology research domain contains 15% (n = 304/2,027) publications and finally, Business Management domain contains 19% (n = 387/2,027). Fig. 12 shows the contributing subject categories assigned by Web of Science.

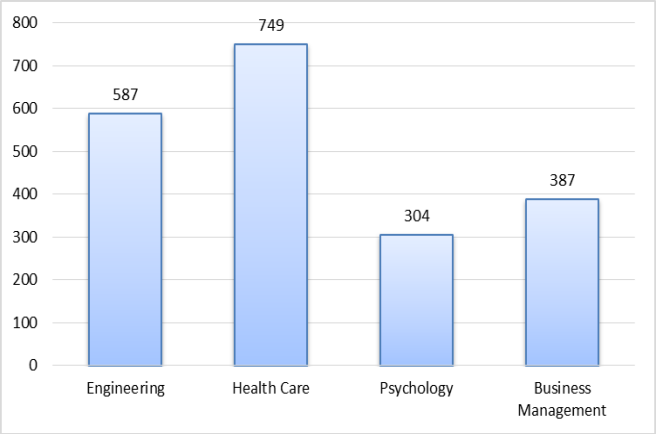

Fig. 12 Overall subject category contribution for safety climate

Although it is not possible to discuss each research work in its detail, after individual assessment of each subject category, it is evident that the health category was the most dominant subject category for safety climate research. Secondly, much of the relationship is also discussed between high-reliability phenomenon and performance in general and safety performance in healthcare settings. Association of safety climate research with engineering subject was also prominent, which depicts its industrial utilization. Followed by this, the business management category was also associated with safety climate research in terms of occupational health and safety, occupational stress, leadership, and employee role. Whereas, psychological research subject was also observed having strong ties with safety climate research.

3.10. Term(s) Analysis

Term analysis was conducted to see the present state of safety climate research and its related or associated research domains. This analysis extracts key terms and words from the abstracts and title of the research. It enables contemporary or future researchers to have an in-depth and larger picture of the current standing, trends, relation, and association of interested research variable(s), term(s), or domain(s). To do this, VOSviewer was utilized to ascertain the graphical results. Safety climate was extracted from all of the 2,027 publication's titles and abstracts. No general term was included in the research. Terms that occur at least five times in publications were included only, and 641 terms fulfilled this criterion.

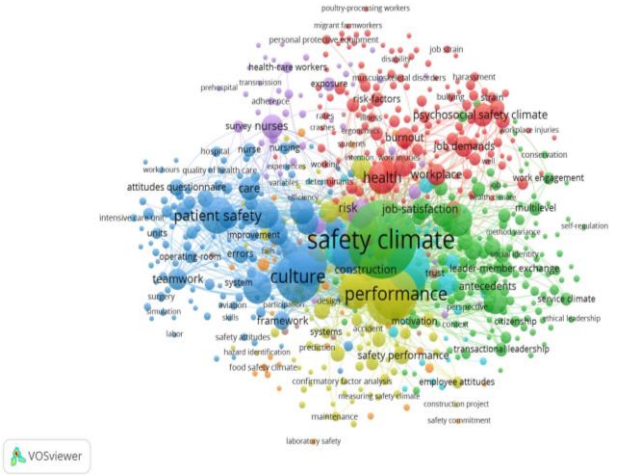

Fig. 13 Term analysis map for safety climate

Figure 13 represents the terms analysis cluster-wise. The size of the single circle shows the occurrence of a certain term, and if it has a large size, then it has a higher occurrence in the title and abstract of Safety climate publications. Secondly, the distance between circles represents the relatedness or relation between two terms; the closer they are, the more related they will be, and its opposite in the case of distant circles. Lastly, the circle color shows their unique cluster within the publications, which is decided based on relatedness with other terms from entire clusters.

According to the term map analysis, eight different but interrelated clusters of safety climate research were observed; a green cluster (center), red cluster-1 (Top right side), blue cluster (Left side), yellow cluster (lower centered), purple cluster at (top left side), orange cluster (scattered under yellow and green clusters), and aqua blue and brown cluster.

We will go by discussing each cluster and its association with safety climate. Firstly, Red cluster is the one that houses 150 specific terms associated with safety climate in different researches. This cluster mainly deals with work-related occupational health and safety issues, i.e., working conditions, workplace psychological conditions, injuries, stress, and support. Personal (age, belief, depression, personality, stress), environmental (job demand, work pressure, compensation, fatigue, insecurity), and social factors (workplace bullying, work-family conflict, etc.) that can enhance or decrement safety are linked with this cluster. Additionally, industries like oil and gas especially (offshore), construction and manufacturing are included in this cluster. Although it is not possible to discuss each term associated with this cluster, it can be seen through this analysis that safety climate is tested in production and service-oriented organizations to enhance safety performance.

Secondly, the Green cluster, the most diverse and intertwined, has ties with almost all other clusters in the network. These clusters accommodate 140 unique terms researched with safety climate. This sector mainly shows the growth and validation of research on safety climate in different contexts. It mainly discusses terms like measurement scale, scale validation, structural equation modeling, analysis technique, and meta-analysis on safety climate. Interestingly this sector also relates role-related variables like job insecurity, job satisfaction, job attitudes, turnover intentions, job performance, and job satisfaction with safety climate. It was interesting to note that this cluster deals prominently with the organizational phenomenon (organizational climate, organizational commitment, organizational justice, organizational trust, organizational climate) and team level variables like mindfulness, which are tested with safety climate. This cluster seems to be testing safety climate at its possible potential with huge diversity. Future authors can get benefit by directly exploring this cluster.

Thirdly, the Blue and Purple clusters are interesting ones. These clusters are mostly linked with the studies related to healthcare organizations, i.e. (hospitals, care centers, ICUs, nursing homes, etc.). These clusters accommodate 172 specific research terms that are associated with safety climate research. It is evident to see from the analysis that safety climate was researched in these clusters to aid safety through the lens of, e.g., patient safety, patient falls, reduced medication errors, medical adversities/emergencies, primary care of the patient, infection control, and mortality. One of the

interesting findings of this analysis was the association of safety climate with the high-reliability organization (HRO) phenomenon, which is yet to be disclosed under less intensive or hazardous organizations. This allows future researchers to related safety climate in other less hazardous organizations. Moreover, these clusters also shed some light on the healthcare workers and the relatedness of the safety phenomenon. Researchers can find and adapt Healthcare related research instruments through this cluster and extend the utility of safety climate in healthcare and other fields.

Fourth, the yellow cluster a relatively small yet much related to other clusters. This cluster houses only 93 terms associated with safety climate research. This cluster is mainly associated with hazards, accidents, and occupational injuries occurring in the construction/manufacturing sector. At the same time, contextual factors like hazardous environment, dangerous workplace, national and local culture, safety, and management systems are also related to safety climate research. Quantitatively, structural equation modeling is mainly applied in the analysis of most of the researches for validation and result generalization.

Further, we have an aqua/light blue cluster that has accommodated 38 key terms. This research cluster mainly deals with the assessment of behavioral indicators of safety performance, i.e., safety compliance and safety participation in the context of transportation, traffic safety climate, driving behavior, locus of control, etc. theory of the planned behavior mainly dominates in this research cluster which shows pathways for future researchers to validate the same in other settings empirically. Lastly, we have Orange and Brown clusters which contain 31 and 17 key terms, respectively. These clusters mainly deal with food safety climate and culture, laboratory safety, human error, psychological contrast, supervisor impact, and safety outcome related to food and its consumption. Factors like, risk-assessment, risk management, safety commitment, safety leadership, safety perceptions, safety training are also tested with safety climate in this cluster, which adds more diversity for safety climate research.

Additionally, it would be interesting to see the latest usage of terms associated with safety climate to see the direction of future research. In doing so, VOSviewer was used to generate the term map showing the time-related information. Terms with time information are shown in Fig. 13, in which the color of a term shown the average time usage of a term concerning publication year. Terms that were more recently used in the last two years are shown in yellow (right side of Fig. 14), and those terms used before 2016 are shown in greenish and blueish colors.

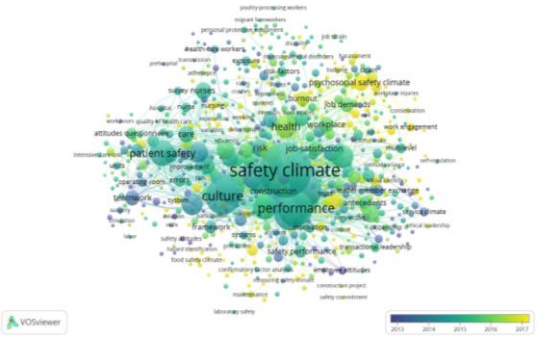

Fig. 14 Term analysis with a timeline for safety climate

After assessing Fig. 14, it can be stated that in the year 2013 to 2014, much of the research was conducted in the healthcare sector on the elements like patient safety, patient care, intensive care units, mortality rate, healthcare reliability, and performance-related variables. From 2014 onward, there is a clear shift of research from healthcare sectors to other production output-oriented settings. From the latest trend starting from the year 2017 onwards, it can be observed that other person-oriented factors like psychosocial hazards, psychological health, burnouts, workplace conditions, job demand, job stress, etc., are being tested with safety climate. Recently, the application of safety climate can also be observed in the food safety sciences by including variables like food safety climate and food safety culture. Finally, the map shows an overall increasing trend in qualitative and meta-analytic studies on safety climate. To sum up the key terms and time map analysis of Safety climate research, it is evident to see the movement of safety climate research from theoretical to quantitative. Alongside this, the importance is given to high reliability, safety performance, individual factors, organizational factors, and contextual factors are prominent.

Through this study, overall growth and evolution of safety climate research were performed from 2005 to 2021. This study includes 2,027 publications on safety climate covering 5,723 authors, 2,092 organizations and institutions, 686 journals, and 90 countries. Safety climate was first coined by Dr. Dov Zohar in 1980 under the broader concept of organizational climate and specifying it to safety climate. Safety climate research has gained notable growth over the period. The research in this field has reached its consolidation stage, where learning is enforced and practically applied in different fields. The variability and versatility of Safety climate research can be seen through its application in industries like oil and gas [46], engineering & chemical processing [47], construction [18], health-care [48], manufacturing [49], maritime [50], mining [51], nuclear [52], transportation [53], air traffic control [29], [54], [55], military and aviation industry[56], [57]. The most acknowledged and cited works are from John B Sexton, Michael S. Christian, Andrew Neal, and Dov Zohar [37],

[41]–[43], [58]. Whereas, work by Dov Zohar [9] is widely considered as principal and foundation for safety climate.

4. Conclusions

Out of this research, there are some of the key takeaways for readers in the coming paragraphs.

Publication output on safety climate has increased overtime time. However, for the last three years, on average, a 09% growth was observed in the publication trend, which is quite low compared to previous years.

A part of the authors (16%) secured no citation for their published work. This may be caused by the utility and content of the research being produced and compel future authors to produce influencing work. At the same time, 68.85% of authors were cited in at least one publication on safety climate. Most influencing or outstanding work is produced by a handful of authors (3.05%) of the total 5,723 authors. This fact is encouraging for future researchers to coin new and novel ideas so that their work is more prominent in the world of academia.

Out of 2,027 publications, only the small group of researchers, i.e., 18 authors, produced about 17% (345 articles) of research on Safety climate. This result shows that more collaborated research is needed to add more diversity to research output.

Out of 686 journals publishing on safety climate, 63% only published one research work. This implies that safety climate research has yet to contribute much more in literature, requiring more coverage in diversified publication bodies.

Safety science is the leading Research Journal working on safety climate having, published 187 research work as of January 2021.

Of the 90 countries publishing on Safety climate, 32% of the (29) countries only published one or two research articles. The USA is the leading producer of scholarly work, having a 37% contribution in a total of 2,027 publications. This is an interesting finding, as it shows saturation of literature towards the USA, China, and Australia and provides room for other countries to conduct more research on Safety climate. From the continental distribution perspective, Africa is the only continent that has conducted the least amount of research on Safety climate. Moreover, considering the overall contribution of countries publishing on Safety climate, geographical inequality was also observed.

Out of 2,092 Universities and Institutions publishing on Safety climate, 65% of them managed to produce or contributed to one research work. Institutions from the USA are in the leading position in terms of contribution with 8% in total. The findings above are useful for institutions, universities, and future researchers to conduct more research on Safety climate.

It was unexpected to observe that 16.5% of the researcher could not secure a single citation for their work, which is a huge portion. There could be several reasons associated with the no-acknowledgment of such works, but quality publication through a reputable platform can provide more coverage for scholarly work. Notable scholarly works and authors are from the USA (1,965 citations), Israel (3,066 citations), and Australia (1,216 citations), showing the frontiers of Safety climate research.

Talking about the prominent figures in safety climate research, the bibliographic analysis revealed that Dov Zohar (Israel), Maureen F. Dollard (Australia), (Yueng-Hsiang) Huang (USA), Thomas A. Arcury (USA), Sara A. Quandt (USA), Jin Lee (USA) Morten Birkeland Nielsen (Norway) and Gil Luria (Israel) are the most influencing figures with a notable number of publications and citations. Most of the researchers are directly or indirectly connected, which shows their centrality and connectivity to the safety climate.

It was interesting to know that Health-care is the only sector that has the highest number of publications on safety climate, followed by engineering, business management, and psychology. The finding above implies that more research is needed in the business management and psychological sector for maximum extraction of benefits from this construct.

Recent studies do not show that factors like psychosocial hazards, psychological health, burnouts, workplace conditions, job demand, job stress, food safety climate, and food safety culture are given more emphasis concerning safety climate.

There are certain facts associated with safety climate research derived from bibliometric analysis. First and foremost, it can be concluded based on the finding that more collaborative research work is required on safety climate, as much of the present work is confined to most western countries or countries which are economically sound.

Secondly, the prior application of safety climate in other (sensitive and high-reliable) industries mentioned earlier resulted in positive outcomes which exhibit its potential and utility in other occupational settings. Finally, the geographical inequality of safety climate research was also observed. The research in very few

numbers in most Asian and African countries was observed, which provides a huge opportunity for researchers from these continents to explore safety climate construct.

To sum up the conclusion and address the novelty aspect, our study is unique as it has unveiled multiple aspects of safety climate research in one go. This multifaceted research can provide a holistic research overview for those researchers who opt to choose a safety climate research construct in the future. Further, the research community can observe the past and emerging patterns through the outcome of this research, which would be extremely beneficial not just for individuals but also for organizations, especially those operating in less or even extremely tiring conditions. Our research outcome is also unique as it provides the rationale for global research communities to initiate collaborative efforts to expand this phenomenon on a much wider scale, especially in developing countries and underdeveloped countries.

Our findings are also unique for academicians researching safety climate construct, as they can identify key authors, their notable works, key institutions, and organizations working on it through our study outcome. Moreover, that may help them to choose their research networks and future collaborators.

5. Study Limitations

There are certain limitations associated with bibliometric analysis. Firstly, the bibliometric technique has no control over the quality or the content of the research (in a qualitative manner), but it deals with the content more quantitatively. Secondly, we used the data extracted from the Web of Science, one of the largest global data sources, and a limitation to cover the entire literature available globally. Another limitation is the period provided by Web of Science (Core database) to extract data covering 2005-2021 (because of the available complete data for research articles). However, it is possible to have related work that could have been carried out earlier and may not be included in this research work.

Lastly, another limitation associated with bibliometric is that, if the same construct is researched under the Web of science domain, it may yield different data set for downloading and analysis through VOSviewer, as the database is increasing and changing every day, thus escalating a time limitation for this kind of studies. Nevertheless, with all such limitations, it is interesting for readers and researchers to look at the present standing of the contract being researched via this technique.

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