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Exploring Current and Future Research Trends on Safety Climate in Construction Projects

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ABSTRACT

Clients, consultants, and contractors in the construction industry can benefit from a safety climate by obtaining knowledge of attitudes and perceptions for better safety outcomes. However, the current and future research trends for safety climate in construction projects have not yet been fully examined. In order to solve this problem, a systematic review of previous research findings using a social network approach must be conducted, and future trends for the safety climate in building projects must be identified. Sixty-three peer-reviewed articles were gathered to study the literature on safety climate in construction projects. A social network approach was employed using VOS viewer to look at the connections between the researchers and the article's keywords. Based on the frequency of researcher collaboration and the connections between the keywords used in the publications, five research groups and four keyword themes were identified using the social network analysis results. The scholars received substantial implications and insights on the state of the research and future directions, which helped create a focused development strategy for safety climate in construction projects. The scope of this study is limited to publications on the subject matter from 2000 to 2021, which provided the base for the current and future research trends on safety climate in construction projects. The findings from this social network analysis revealed that studies on safety climate are more skewed to the organizational level than the project level. In developing countries like Tanzania, studies are scanty. Also, different levels of decision-making within the organization and within construction projects, call for different safety factors whereby the current studies have slightly considered such a fact. Furthermore, it is the right time now for researchers to focus on developing a safety climate maturity framework for construction projects.

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INTRODUCTION

The likelihood of deadly incidents in the construction sector, for instance, falling or being hit by things, is significant (Amiri et al., 2016; Han et al., 2021; Lee et al., 2021; Mhetre et al., 2016; Pinto et al., 2011). The risks associated with the construction industry are complex and affected by the conditions of the construction site, particularly changes or levels of management, and site workers' technology. In Tanzania, according to the data from the National Bureau of Statistics (NBS) in 2020, the construction industry is growing progressively, and it is the second leading contributor to the real Gross Domestic Product (GDP) growth after Agriculture. Agriculture contributed about 26.9%, followed by construction at 14.4%, accommodation, and restaurants at 10%, while trade and repair contributed about 8.4% (National Bureau of Statistics, 2022) shown by Figure 1.

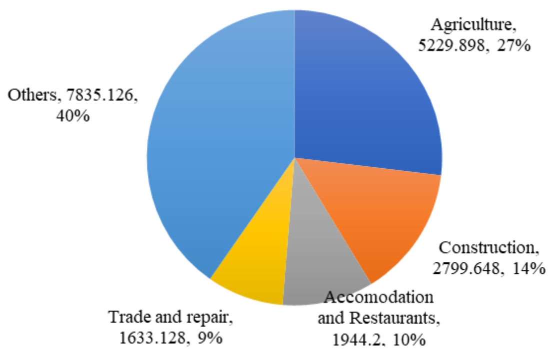

Figure 1: GDP contribution (in billion Tanzanian shillings) (NBS, 2022)

Despite of the contribution to the economic growth, accidents, injuries, and diseases among workers in construction industry are also increasing at a progressive rate. For example, according to a 2012 Occupational Health and Safety (OHS) assessment carried out in Tanzania, mortality rates vary by industry, ranging from 0.12% to 24%, with the construction industry leading the pack, followed by the transport and mining industries. (Mrema et al., 2015).

However, the mortality toll at building sites throughout the world is also at extremely high levels. The International Labor Organization reported that Israel had the highest rate of construction site fatalities, with 24.8 fatalities per 100,000 employees, followed by Mexico (19.5), South Korea (17.6), Portugal (15.6), Estonia (13.8), Turkey (13.4), Slovenia (12.5), and the Czech Republic. (ILO, 2016). In order to reduce accident rates in the construction business, it is necessary to understand the root causes of such safety mishaps and develop a solution. (Hofmann & Stetzer, 1998; Mearns et al., 1998; Shaikh et al., 2020; Wu et al., 2015). This research paper is established to encounter the main objective, which is to determine the research gaps associated with safety climate practices in construction projects.

LITERATURE REVIEW

Fatalities in Construction Industry

The number of deaths in the construction sector in the United States of America increased by 5% in 2019 (BLS, 2019).The year 2019 was the highest number of fatalities among construction workers (1,061) since 2007. Over the previous ten years, the U.S. construction industry has contributed around 20% of all deaths, although employing only 4% of the country's workers. (Al-Bayati et al., 2019; Liu et al., 2020). Construction had a 71% higher non-fatality injury rate than all other sectors combined (Waehrer et al., 2007). Furthermore, according to Bureau of labour Statistics (BLS), there are now around 50 occurrences per 10,000 full-time equivalent construction workers that require days off from work, up from the previous year BLS (2019b). As a result, both fatal and nonfatal injuries are dramatically increased by the building sector (Niu et al., 2017).

Meanwhile, despite the increase in accident rates in developing countries, the accidents in developed countries have significantly decreased. For instance, statistics show that the average number of worker fatalities in America has decreased from roughly 38 per day in 1970 to 12 per day in 2014. From 10.9 incidences per 100 employees in 1972 to 3.3 incidents per 100 in 2013, there have been less worker injuries and illnesses. (OSHA, 2014).

Also, the accident rates in Hong Kong for example, during the period from 1996 to 2016 have decreased from 220 accidents per 1000 workers in 1996 to 35 accidents per 1000 workers in 2016 (Figure 2). This may be due to the saturation of construction activities in some developed countries unlike in developing countries where the construction sector is expanding exponentially (Yiu et al., 2019). In the case of the local industry in Tanzania, it employed between 9% and 11% of the total workforce but was the sector with the highest rate of deaths in 2012, with a rate of 23.7%. It also employed between 25 and 45 percent of all occupational fatalities in the nation (Mrema et al., 2015).

Tanzania has built a variety of institutional forms of machinery to guarantee that employees are safe on building sites that control occupational health and safety and give numerous laws and regulations that govern safety in the nation's building (Table 2). Despite all those efforts, there is still a growing number of accidents and fatalities in construction sites which may range from slips, trips, and falls from the buildings to electric shocks and manual handling.

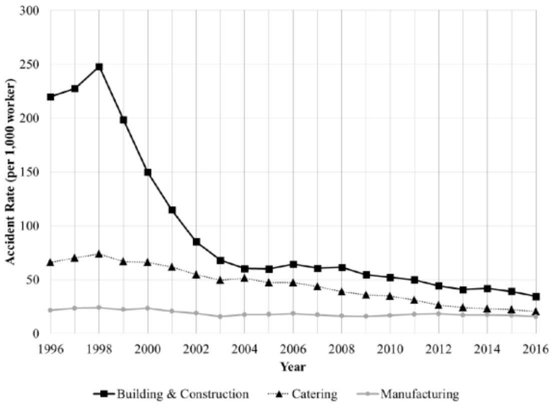

Figure 2: Accident rates of three major industries in Hong Kong (1996–2016) (Source: Yiu et al., 2019).

Table 1: 2012 Tanzania fatality rate by sector (Mrema *et al*. 2015)

Sector	Total employed	Number of Fatal injuries ×1000	Fatality Rate (%)
Construction/Building	151,690	36	23.73
Transport	111,571	23	20.61
Mining and quarrying	29,223	6	20.53
Manufacturing	245,449	28	11.41
Commerce and Distribution	2,486,818	12	0.48
Agriculture, Forest, Fishing	13,890,054	16	0.12
Total	16,914,805	121	

Table 2: Occupational health and safety–related legislations (Mrema et al. 2015)

S/N	OHS-Related Legislations	Administering Ministry/Agency
1	The Pharmaceuticals and Poison Act (1978)	Ministry of Health and Social Welfare
2	The Tropical Pesticides Research Institute Act (1979)	Ministry of Agriculture
3	The Fire and Rescue Services Act (1985)	Ministry of Home Affairs
4	The Industrial and Consumer Chemical Act (1985)	Government Chemist Laboratory Agency
5	The Plant Protection Act (1997)	Ministry of Agriculture
6	Mining Act (1998)	Ministry of Energy and Mineral Resources
7	The Atomic Energy Act (2003)	Ministry of Science, Technology, and High Education
8	The Employment and Labor Relations Act (2004)	Ministry of Labor, Employment and Youth Development
9	Workers Compensation Act (2008)	Ministry of Labor, Employment and Youth Development
10	The Public Health Act (2009)	Ministry of Health and Social Welfare

Additionally, the majority of employees in the construction industry do not have formal work contracts and are instead employed on an as-needed basis. They work irregular hours and on a temporary basis, and they frequently don't have access to Personal Protective Equipment (PPE), policy statements, or the enforcement of safety regulations on the job site (Aikaeli & Mkenda, 2015; Mrema et al., 2015; Wells & Jason, 2010). To resolve the problems, several studies on safety have recently been conducted and adopted the concept of safety climate to determine the ultimate causes of safety accidents and influence the perception of a safe environment (Figure 3).

Safety Culture and Safety Climate

There is still a lot of confusion about how safety culture and safety climate are defined, related, and measured in practice despite decades of study in these fields. Although safety culture and climate are two distinct concepts, they complement one another. (Kluwer, 2017). It is generally accepted that "safety culture" was first described with the 1986 Chornobyl accident, while "safety climate" was used at least as early as 1980 or even earlier(Goulart, 2013). Safety culture aims to create a good environment where employees are aware of hazards and accident prevention (He et al., 2012). According to Goulart **(**2013), safety culture is a subset of safety climate (Figure 4). Other subsets of safety climate are behavior safety and safety management system. Table 2 offers the current definitions, however, that have been put out by a few organizations including the Center for Construction Research and Training (CPWR). Table 3 offers the safety climate and culture definitions in use currently.

Safety area dimensions

Several studies have established numerous safety dimensions and indicated several predictors which predict different research domains. Table 4 consists of a list of Safety dimensions, safety predictors, and safety outcomes by different researchers.

Figure 3: Influence of safety climate (Gershon et al., 2000)

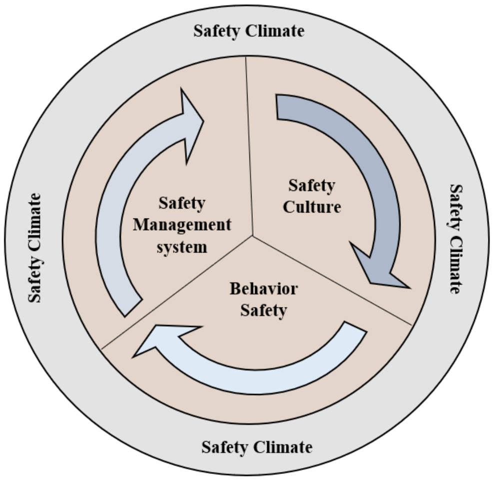

Figure 4: Safety climate and culture relationship (Goulart, 2013)

Table 3: Current safety culture and safety climate definitions (Al-Bayati et al., 2019)

Agency	Safety culture	Safety climate
NCA (National Construction Agenda, 2018)	The underlying organizational beliefs, norms, commitments, and principles that govern how safety and health are	The shared employee perceptions and attitudes on workplace safety. It captures the safety culture at a

Agency	Safety culture	Safety climate
	operationalized and how important they are concerning other workplace objectives	specific moment.
OSHA (Occupational Safety and Health Administration, 2000)	Consists of shared attitudes, behaviors, and practices that exist inside an organization. The environment that is produced by the ideas, attitudes, etc. that influence human behavior is known as culture.	(Silence)
NRC (Nuclear Regulatory Commission, 2018)	A collaborative commitment by leaders and individuals to prioritize safety over conflicting objectives to secure the protection of people and the environment led to the development of core values and practices.	(Silence)
CPWR (Gillen et al., 2014)	Deeply held but frequently unspoken safety-related attitudes, values, and beliefs that interact with the systems, procedures, staff, and leadership of an organization to create norms for how things should be done there. Organizational culture influences and is a component of safety culture. Organizations frequently have numerous cultures or subcultures, and the construction industry may be especially susceptible to this.	The collective opinions of a group of employees about a company's safety policies and practices at a specific period, particularly about how well they are implemented and how closely they reflect the real situation. Within a company, between-group discrepancies are widespread, although homogeneous subgroups tend to acquire shared perceptions.

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Table 4: Safety dimensions for safety areas research

Safety areas	Safety dimensions	Authors
Safety climate	The management team, coworkers, and background of the employee	(Mosly, 2019)
	Individual safety awareness and safety behavior to examine multilevel relationships	(Wang et al., 2018)
	Supervisor's safety role, management commitment to safety, safety rules and procedures, individual responsibility to health and safety, and training	(Alruqi et al., 2018)
	Resources for safety and their effectiveness, risk-taking behavior, and perception of work risk, workers' perception of safety rules and procedures, workers' personal involvement in safety and health, safety working attitude and workmate's influence, and safety promotion and communication are all factors that affect the safety climate.	(Chan et al., 2017)
	Rules and procedures, employee participation, understanding of personal risk, communication, and supervisory environment	(Niu et al., 2016)
	Process for safety management, employee behavior, employee perception, and statistics on accidents and incidents	(Zhou et al., 2015)
	Top management's commitment to safety, the organization's emphasis on safety, supervisors' actions and expectations on safety, coworkers' real and ideal safety responses, and the incidence of lost time and medical care injuries	(H. Lingard et al., 2012)
	Relationships, personal protective equipment, job pressure,	(H. C. Lingard et

Safety areas	Safety dimensions	Authors
	communication and support, adequate processes, and behavior that is mostly safe	al., 2010)
	Risk-taking behavior, safety resources, assessment of safety procedure and work risk, inappropriate safety procedure, worker involvement, workmate influence, and competency are among the factors that contribute to safety attitude and management commitment.	(Fang et al., 2006)
Safety culture	leadership's dedication to safety, A strategy to reporting and analyzing bad events that is not punitive	(Halligan & Zecevic, 2011)
	Commitment to safety by management and the institution (management and supervision)	(Singla et al., 2006)
	Institutional responses (management and supervision)	(Singla et al., 2006)
	Adequate supervision and training (management and supervision)	(Singla et al., 2006)
	non-punitive reaction to mistakes (management and supervision)	(Singla et al., 2006) (Halligan & Zecevic, 2011)
	Organizational culture, which is thought to affect members' attitudes and behavior in relation to an organization’s ongoing health and safety performance.	(Cooper, 2000)
	Equipment, tools, physical layout, and temperature are examples of environmental elements. Personal factors include attitudes, beliefs, and personalities. Behavioral aspects include safe and dangerous work practices as well as going above and beyond the call of duty to ensure the safety of others.	(Geller, 1994)

Overview of existing studies

Several assessment models and tools for different disciplines of construction were reviewed. Those are tools for assessing or guiding the safety climate and maturity growth of construction projects throughout the globe. Although the majority of safety climate studies, including those carried out in the construction industry, have focused on the organization as the unit of analysis, a more fine-grained analysis may be necessary in large and complex modern organizations, particularly when those find common factors for capturing workers' perceptions of how safety climate is managed on construction projects.

The first model was established in 1980 by Zohar in Israel, with 40 items in 20 industrial organizations based on industries involved in metal manufacturing, chemicals, textiles, and food processing. It used factor analysis methods, resulting in an eight dimensions model (Zohar, 1980). Later in 1986, a replicate of Zohar's (1980) model was established by Brown and Holmes for organizations. A new set of three components was established after the confirmatory factor analysis using the American sample revealed that the model was not supported. (Brown & Holmes, 1986). In 1991, three factors found by Brown and Holmes were tested using 384 construction workers in Canada.

Factor analysis methods were used, and a model was supportive of the development of 2 factors solution (Dedobbeleer & Béland, 1991). On the other hand, in 1993 in the US, as they concentrate on risky conduct in an organization before an accident happens, Reber examined whether behavior sample data are better than accident statistics. The model's factor analysis validated the hypothesis. (Reber et al., 1993).

Later, several UK researchers searched for reasons for under-reporting in companies. The factor analysis found that incentive plans are to blame for underreporting. (Cooper, 2000; Geller, 1994; Krause and Russell, 1994; Promfret, 1994). At the same time, US researchers were testing the accident frequency rates in companies using reliability analysis. Because of the data's significant underreporting, it was determined that they were too inaccurate to be used in research investigations. (McCurdy et al., 1991; Stout & Bell, 1991; Thompson et al., 1998).

The Relationship between safety climate and a behavioral observation measure of safety performance in Road construction in organizations was tested in Australia using the factor analysis methods. No relationship was found between safety climate and the safety performance measure (Glendon and Litherland, 2001). On the other hand, Flin tested the "big five" themes of safety climate in the UK using a methodical review and found unjustifiable studies due to methodological inconsistencies and contrasts in language and culture across different nations and industries (Flin et al., 2000).

Later in 2002, the 10 aspects of the safety climate on construction sites were measured in Australia using Structural Equation Modelling (SEM) and a 10-factor model was established (Mohamed, 2002). Furthermore, a 15 factors model for testing the relationship between safety climate and personal characteristics in the construction industry was tested in Hong Kong. Using the factor analysis, eight personal characteristics were found to influence the safety climate (Fang et al., 2006).

METHODS AND MATERIALS

Systematic Literature review

A significant number of papers on this subject (safety climate and its association in the construction industry) have been published worldwide. Whereas since the 1990s, as computer technology has advanced, it has been feasible to find these studies online using various search engines quickly. The systematic literature review (SLR) was first used as a tool for study in this setting. A systematic literature review is the methodical gathering, critical evaluation, integration, and presentation of data from numerous research projects on a certain study topic or area of interest (SLR). The SLR provides a strategy for assessing the amount and caliber of evidence that is available about an issue or topic of interest. It gives a deeper and more precise level of learning than typical literature research (Pati & Lorusso, 2018). SLR is a precise and repeatable approach for identifying, assessing, and interpreting specific academic domains (Wawak et al., 2020). Observing the articles published in the building industry's literature reviews, the majority of the reviews published since 2010 were based on SLR (Babalola et al., 2019; Jamil et al., 2018). Preferred reporting items for systematic review and meta-analysis (PRISMA) have been used in several review articles since 2018 (Charef et al., 2018; Martínez-Aires et al., 2018). However, this study preferred SLR as it is a widely known method for identifying, evaluating, and interpreting predefined fields of study.

Literature Collection and Sources

Using the University of Dar es Salaam (UDSM) online library databases, a representative integrated search platform, data on safety climate trends were first searched. Next, publications were reviewed by corresponding publishers, including Taylor and Francis Ltd, IOS Press, and the American Society of Civil Engineers. Zohar initially proposed the idea of a safety climate in 1980, and Clarke established the relationship between a safety climate and safety accidents in 2006 (Clarke, 2006; Zohar, 1980). Dedobbeleer and Beland conducted a study on the safety climate in the construction industry as early as 1991 (Dedobbeleer & Béland, 1991), although the majority of the systematic literature on the subject was published after 2000. As a result, our study reviewed materials that were published after 2000, the year that a significant number of researches on the connection between the safety climate and accidents started.

By using the keywords "safety climate," "construction site safety," and "safety for workers," a total of 295,780 samples of academic publications were meticulously gathered in full-text versions from the University of Dar es Salaam (UDSM) databases. To ensure the objectivity and dependability of the systematic review of the literature, the sample size was established at 339 papers (Marshall et al., 2013). The research engine's top 284 papers, which showed a high degree of relevance between the articles and the keywords, were chosen after the publisher's limitations were entered. Journal of Construction Management and Economics (106 papers), Journal of Construction Engineering and Management (111 papers), Engineering Construction and Architectural Management (67 papers), Journal of Civil Engineering and Management (28 papers), Works (34 papers), and Sustainability (27 papers) were the five peer-reviewed publications from which the extracted articles primarily came. Lastly, only 63 non-duplicate articles were selected (Table 5).

Table 5: Selection limitation for database articles

S/N	Selection stage	Descriptions	No. of articles obtained
1	"Safety climate," "construction site safety," and "safety for workers,"	Only full-text articles are selected with no time limitation	295,780
2	Scholarly (Peer peer-reviewed)	Only peer-reviewed articles were selected	40,176
3	Years limitation	The limitation was from 2000 to 2022	38,317
4	Academic journal limitation	Only academic journals were selected	38,051
5	Subjects' limitation	Keywords that were specifically related to literature keywords were selected	1,868
7	Journal limitation	Construction Management and Economics (106 papers), Journal of Construction Engineering and Management (111 papers), Engineering Construction and Architectural Management (67 papers), Journal of Civil Engineering and Management (28 papers), Works (34 papers), and Sustainability (27 papers)	339
6	Publishers' limitation	American Society of Civil Engineers (123), Taylor and Francis Ltd (65), IOS Press (96)	284
8	Duplicate removed	Only non-duplicate articles were selected	63

Social network analysis

VOS viewer, a widely used free program for literature network analysis, was utilized in this study to conduct the citation-based network analysis. VOS viewer was created by Nees Jan van Eck and Ludo Waltman of the Centre for Science and Technology Studies at Leiden University. Two distinctive networks were created and examined. The co-author network was created specifically to research the real-world modes of scientific collaboration. By looking at the network of co-authorship, all facets of scientific research collaboration can be properly tracked (Eaton *et al.*, 1999; Yang *et al.*, 2014). A keyword co-occurrence network was created to find terms and themes that frequently occurred in articles that revealed links between specific study topics or research paths (Su & Lee, 2010).

RESULTS AND DISCUSSIONS

Trend in research publications

Using Microsoft Excel version 2013, Figure 5 was developed, and there was just one publication in the field of safety climate in the year 2011; nevertheless, as time has gone on, the number of publications has grown; however, the growth is not steady.

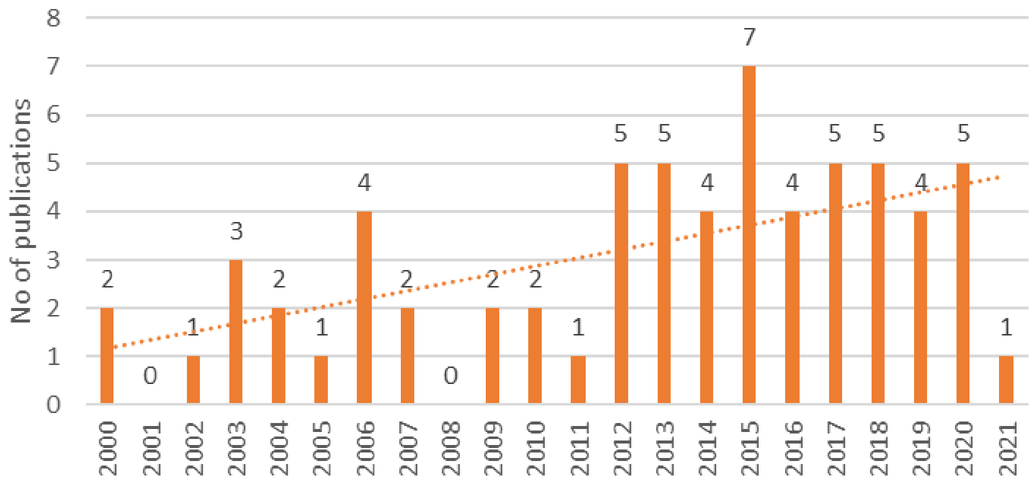

Figure 3: Trend of safety climate publications.

Journals and academic databases used in safety climate publications

Several journals have published studies on the safety climate. Of the five journals that were reviewed for the study, the Journal of Construction Management & Economics has published the most articles in this field. The Figure 5 shows that the journal has published a total of 25 articles, followed by the Journal of Construction Engineering and Management with 22 papers, Work with 7 papers, and Professional safety with 9 articles. On the other hand, The American Society of Civil Engineers, Taylor and Francis Ltd, and IOS Press are the publishers whose articles were gathered for the study. Taylor & Francis Ltd. has published 25 articles, the most of any of the publishers that were used, followed by the American Society of Civil Engineers with 22 articles, the American Society of Safety Engineers with 9 articles, and the IOS with 7, as indicated in the Table 6.

A total of 227 authors contributed to the 63 articles in this study. A threshold was established to eliminate those unrepresentative researchers by limiting the number of documents that one author had written to no more than two. The 63 publications' authors whose names appeared just once were excluded from the data analysis (Van Eck & Waltman, 2014). Last but not least, 16 authors were set aside to create the co-authorship network's-authorship analysis was used to group the 16 authors into five groups. Table 7 and Figure 6 show the classification information in full.

Table 6 : Journals and academic databases used in safety climate publications

Item	Title	No. of articles	Freq. (%)	Cum. Freq.

Item	Title	No. of articles	Freq. (%)	Cum. Freq.
Academic Database	American Society of Civil Engineers	22	35	35
	American Society of Safety Engineers	9	14	49
	Taylor and Francis Ltd	25	40	89
	IOS Press	7	11	100
Journals	Journal of Construction Management & Economics	25	40	40
	Journal of Construction Engineering and Management	22	35	75
	Work	9	14	89
	Professional Safety	7	11	100

Source: UDSM Online Library

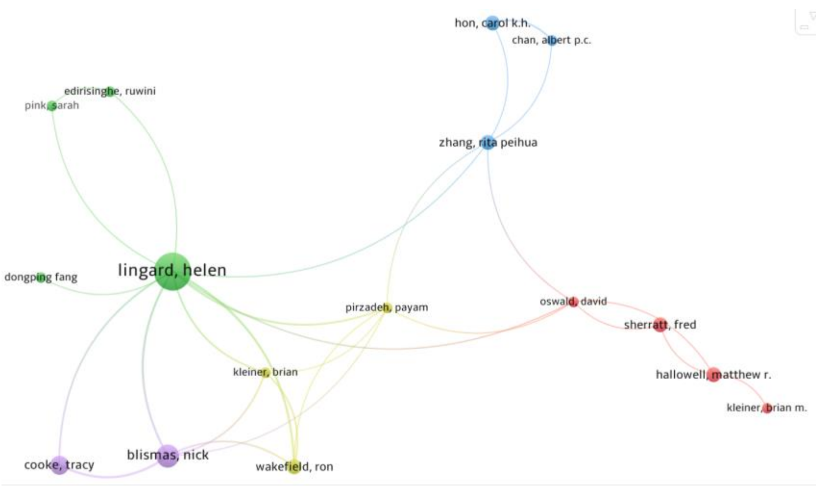

Figure 4: Co-authorship networks.

Table 7: Cluster classification of authors

Cluster 1 (Red)	Cluster 2 (Green)	Custer 3 (Blue)	Cluster 4 (Yellow)	Cluster 5 (Purple)
Hallowell, Methew R.	Dongping,Fang	Chan, Aldert P.C.	Kleiner, Brian	Blismas, Nick
Kleiner, Brian M.	Edirisinghe, Ruwini	Hon, Carol k.h.	Pirzadeh, Payam	Cooke, Tracy
Oswald, David	Lingard, Helen	Peihua Zang, Rita	Wakefield, Ron	
Sherratt, Fred	Pink, Sarah			

Four writers participated in cluster 1, as shown in Table 7. By working with clusters 4 and 3 through Zang, Pirzadeh, Oswald and Lingard were able to establish a connection to cluster 1. Sherratt Fred and Hallowell Mathew R were the primary researchers in cluster 1 because, as seen in the above diagram, the nodes that represented them had the largest node sizes overall in cluster 1. They had the strongest link since they collaborated with others more frequently. Sherratt Fred's primary research area influenced the discourse on worker health in the UK construction sector (Sherratt, 2018). In contrast, Hallowell Mathew R. centered on figuring out how language proficiency, communication styles, and safety performance in small work crews in the United States relate to one another (Alsamadani et al., 2013).

Figure 5: Co-authorship networks of cluster 1.

The co-authorship network for cluster 4, where the most active researcher was Pirzadeh, Payam who out of the three authors had the largest node, as shown in Figure 8. All of the remaining academics have worked with Lingard Hellen. Pirzadeh, Payam collaborated with Zang Rita Peihua in several publications. The creation and development of a multidimensional safety climate measurement instrument for the construction sector have been Zang Rita Peihua's primary research interests in recent years (R. P. Zhang et al., 2015). Zang Rita Peihua collaborated with other writers to establish The impact of supervisory safety communication on safety climate and behavior in construction workgroups and other relevant studies (Cheung & Zhang, 2020; Li et al., 2020; H. Lingard et al., 2019; R. P. Zhang et al., 2018, 2020; X. Zhang, 2017).

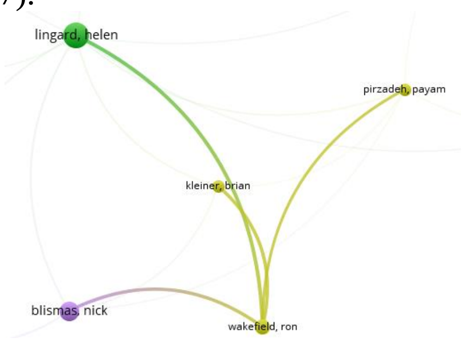

Figure 6: Co-authorship network of cluster 4.

For cluster 2, Figure 9 illustrates that Lingard Hellen worked most frequently with other scholars. Lingard's research interest was mainly related to safety climate measuring tools in the construction industry (Choudhry et al., 2009; R. P. Zhang et al., 2015). The Safety climate in conditions of construction subcontracting: Using a safety climate survey conducted at a sizable hospital construction project in Melbourne, Lingard used a multi-level analysis developed for the Australian construction industry to determine how subcontracted workers perceived the organizational safety response (OSR) and supervisor safety response (SSR) in their organization and that of the principal contractor. (H. C. Lingard et al., 2010). The interrelation between clusters 2 and 5 was achieved due to the cooperation between Lingard, Blismas, and Cooke in the research on the properties of group safety climate in construction (Helen et al., 2010).

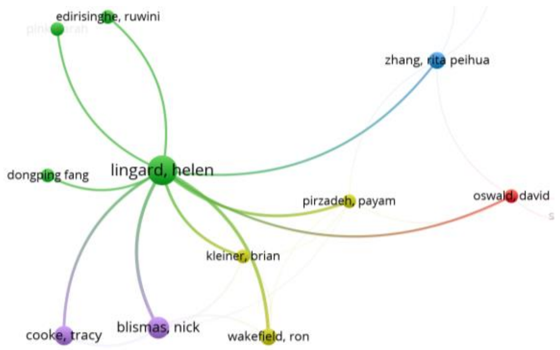

Figure 7: Co-authorship network of cluster 2.

Figure 10 shows that there were three authors in the network of cluster 3, with Wakefield Ron being the most significant due to his frequent partnerships with other authors. Recent academic accomplishments of Wakefield Ron show that he is interested in measuring health and safety performance in the construction business. (H. Lingard et al., 2013). The project Occupational Health and Safety performance in the construction industry was also the research interest of Wakefield and his coworkers (H. Lingard et al., 2011).

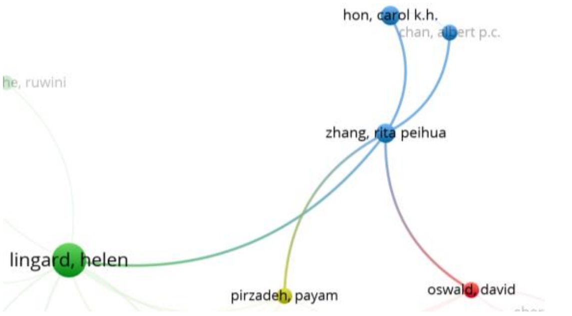

Figure 8: Co-authorship network for cluster 3.

Figure 11 shows that there were two authors in the network of cluster 5, with Bismas Nick being the most significant due to his frequent partnerships with other authors. The general link between all clusters was mainly established between Lingard Helen, Wakefield, Ron, Pirzadeh Payam, Zang Rita Peihua, Oswald David and Blismas Nick in their various publications.

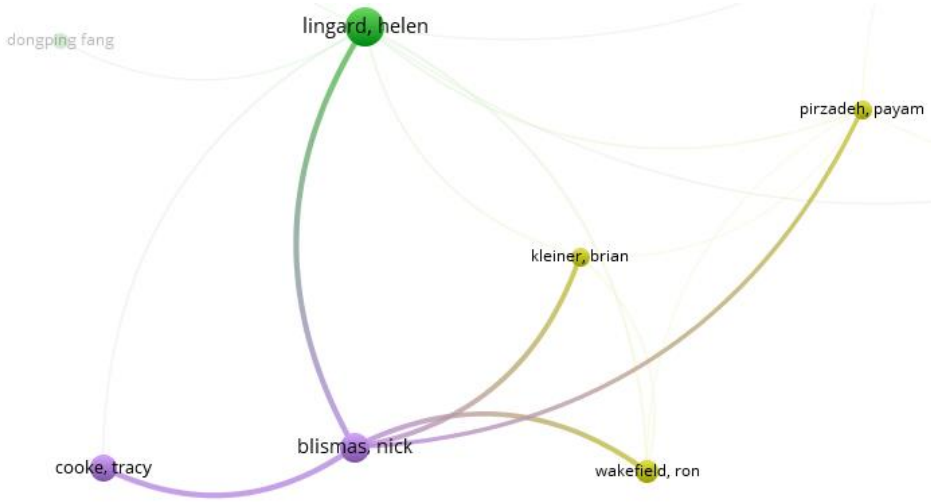

Figure 9: Co-authorship network for cluster 5.

Keyword co-occurrence network

The network linkage between the various nodes was created by the co-occurrence of the author's keywords. Based on bibliometric information, 224 author-specified keywords were retrieved from 63 publications. After establishing a criterion of keyword co-occurrence more than four times to eliminate pointless correlations for further simplification, 12 keywords were ultimately left. (Van Eck & Waltman, 2014). The cluster classification of all keywords is provided in Table 8, and Figure 12 shows the findings of the network analysis. After their magnitudes, the clusters were assigned numbers ranging from 1 to 4.

Table 8: Classification for keywords

Cluster 1 (Red)	Cluster 2 (Green)	Custer 3 (Blue)	Cluster 4 (Yellow)
Construction industry safety	Health and safety	Building sites	Accidents
Safety climate	Industrial hygiene	Construction project management	Occupational safety
Survey	Regression analysis	Work environment	
Work related injury			

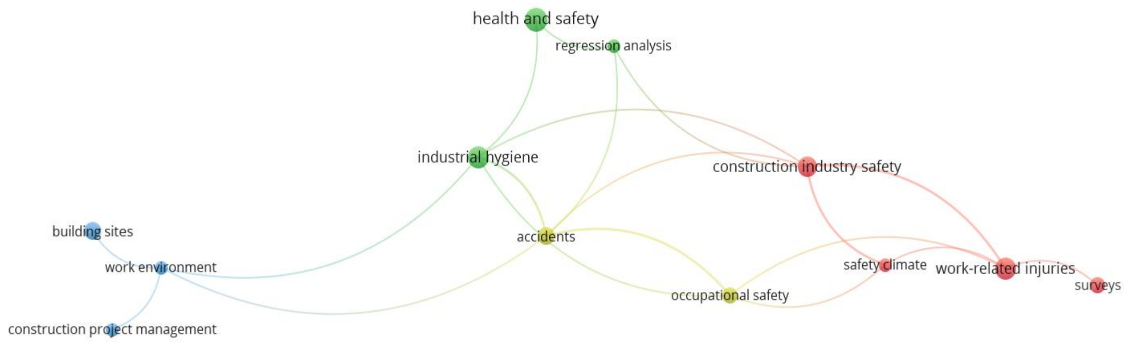

Figure 10 : Co-occurrence network for keywords of collected papers.

Cluster 1 mainly included safety constructs and factors that have recently received much attention from scholars, such as safety climate, survey, construction industry safety, and work related injury were mainly applied as mediating variables in the regression analysis among safety concepts(Choudhry et al., 2009; H. Lingard, Zhang, et al., 2015; H. C. Lingard et al., 2010). Survey keyword was discussed as tools for assessing Multilevel Safety Culture and Climate (Chen & Jin, 2013; Sacks et al., 2009).
The definition of accidents is presented as a way of examining occupational safety so that they may be better avoided, reduced, or otherwise managed, which is the main topic of cluster 4 (Andersen et al., 2018; Grill et al., 2019). Similarly, it was seen as a keyword which was established a link between different literatures as seen in the co-occurrence network for keywords above. Also, health and safety and work environment were the key themes in clusters 2 and 3. Numerous researchers have focused on Health and safety and work environment studies to improve health and safety in the construction industry (Kim, 2021; H. Lingard, Pink, et al., 2015; Oswald et al., 2018). On the other hand, several studies have done research on how to improve industrial hygiene by establishing a good work environment by improving construction project management in building sites (Borgheipour et al., 2020; Kearney et al., 2017; Smith, 2019).

Frequency of occurrence of the keyword in publications

Table 9 shows some of the keywords with the highest appearance in the articles that were gathered and reviewed based on the analysis done using VOS viewer. The study reveals that there have been several publications published in the field of safety climate. A systematic literature review on the current and future research trends on the topic of safety climate in the construction industry was undertaken. Both the relationships between the authors on the research publications and the co-occurrence of the keywords on the most recent papers published were demonstrated. After conducting a thorough review of all articles from 2000 to 2022 by using VOS Viewer, several issues were observed. First, although the trend of publishing on safety climate is increasing, there is a small number of published articles in the year 2021 compared to 2015 (Figure 5). This may be caused by the decrease in challenges associated with the safety climate in construction projects in the developed world. Based on social network analysis using VOS viewer, Work-related injuries, Industrial hygiene, Health and safety, and Construction industry safety had a higher frequency of occurrence than the rest of the keywords (Table 9). Most safety climate articles were based on data from developed nations, whereby it is well-known that people in developed nations have a high level of knowledge and awareness of safety climate issues attributed to high construction technology (Yiu et al., 2019).

Table 9: Occurrence of the keywords in publications

Keyword	Occurrences	Total link strength
Work-related injuries	8	34
Construction industry safety	7	32
Industrial hygiene	8	30
Accidents	6	27
Health and safety	9	27
Occupational safety	5	22
Regression analysis	4	21
Survey	5	21
Building sites	6	17
Safety climate	4	17
Work environment	4	13
Construction project management	4	12

An increase in safety climate trend was observed in 2015 due to the rise of safety climate challenges in developed nations caused by the rise of the construction of the biggest infrastructure. Therefore, it can be argued that safety climate awareness is needed in developing countries with booming economies associated with a significant increase in infrastructure investment.

On the other hand, many researchers have increasingly recognized the importance of measurement as part of diagnosing complex projects, particularly mega construction projects. It should be noted that the more complex the project is, the riskier the project and the more complex the safety climate is. Accordingly, there are six frameworks of project complexity, including technological complexity, organizational complexity, goal complexity, environmental complexity, cultural complexity, and information complexity (Baccarini, 1996; Maylor, 2003; Maylor et al., 2008; Remington & Pollack, 2007; L. Vidal et al., 2010, 2011; L. A. Vidal & Marle, 2008; Williams, 1999). This review study observed the limitations of current researchers to consider the issue of project complexity and safety measurement concerning the level of safety climate within the project.

The project team's level of project management maturity may affect the construction project's safety climate. The higher project management maturity is, the higher the safety climate is for a particular construction project. Also, as the project reaches its completion, it must pass through different maturity levels. The final safety level may depend on several previous project management maturity levels. If the safety climate on individual management levels was not well enough may lead to a poor safety climate at project completion levels (Probst et al., 2019). The current researchers failed to establish the association between project management maturity and the safety climate of a construction project.

Also, every construction project runs with different project risks from initiation to completion. The safety climate in the initiation phase may differ from the completion phase. However, planning for mitigation of risks (planning for safety climate) at the initiation phase may reduce the high risks of safety climate on completion. The researchers failed to outline the project phases and their contribution to the safety climate of the construction project.

Finally, all the literature assumed that the same individual gives the decisions made within the construction project gives the decisions made within the construction project at the same management level. In reality, safety climate decisions in construction projects are made at different managerial levels. The safety climate decisions made at the strategic level are completely different from those at the operational level. Therefore, there is a need to assess the relationship between the level of safety climate and the level of decision-making within the construction projects.

CONCLUSIONS

The findings from this social network analysis revealed that studies on safety climate are more skewed to the organizational level than the projects level and in developing countries like Tanzania, studies are scanty. Also, different levels of decision-making within the organization as well as within construction projects, call for different safety factors, whereby the current studies have slightly considered that fact.

On the other side, there hasn't been any discussion of the complexity of the projects, particularly how it affects the environment for safety within the construction project which marks the appropriate prospect for future safety climate topics. Additionally, scientific and technological advancements have resulted in the development of significant techniques for the examination of complicated issues like safety climate. The implication of this research is to fill the safety climate gap observed in the literature due to a deficit in some knowledge involving safety climate in construction projects. Furthermore, the fluctuation of UDSM online library database was one of the biggest limitations due to the continuous change in the number of articles obtained every time the selection process was conducted. Therefore, it's time for researchers to concentrate on creating a framework for safety climate maturity for construction projects being built in both wealthy and developing nations. After looking at different research gaps observed in this research, a study has recommended future studies on the following major areas:

- Future studies are recommended to establish statistical figures for safety climate practices.
- Future studies are advised for developing the relationship between the project complexities on the safety climate of the construction project.
- The research on the association between project management maturity and the safety climate of the construction project should be implemented.
- A need to research the relationship between project phases and their contribution to the safety climate of the construction project.
- Future studies on the relationship between the levels of safety climate versus the level of safety outcomes within construction projects are recommended.
- The use of other methods of analysis, such as Structural Equation Modelling (SEM), System Dynamics Modelling (SD), or Soft Systems Methodology (SSM) in

future studies is recommended.

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