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Review of global mental health research in the construction industry: a science mapping approach

Abstract

Purpose- The demanding nature of the construction industry poses strain that affects the health of construction personnel. Research shows that mental ill health in this industry is increasing. However, a review mapping the field to determine the extant of research is lacking. Thus, this paper conducts a scientometric review of mental health research in the construction industry.
Design/methodology/approach- A total of 145 bibliographic records retrieved from WoS and Scopus database were analyzed using CiteSpace, to visualize mental health research outputs in the industry.
Findings– Top co-cited authors are Helen Lingard, Mei-yung Leung, Paul Bowen, Julitta S. Boschman, Peter E.D. Love, Martin Loosemore, and Linda Goldenhar. Previous studies focused on healthy eating, work efficiency, occupational stress, and workplace injury. Emerging research areas are centered around physiological health monitoring, work ability, and smart interventions to prevent and manage poor mental health.
Research implications- Result is influenced by the citations in retrieved articles.
Practical implications- The study found that researchers in the construction industry have intensified efforts to leverage information technology in improving the health, well-being, and safety of construction personnel. Future research should focus on developing workplace interventions that incorporate organizational justice and flexible work systems. There is also a need to develop psychological self-reporting scales specific to the industry.
Originality/value- This study enhances the understanding of researchers on existing collaboration networks and future research directions. It provides information on foundational documents and authors whose works should be consulted when researching into this field.

Keywords: Mental health, Scientometric review, Construction personnel.

Introduction

The workplace is becoming more stressful as a result of intensified work assignments (European Agency on Safety and Health at Work, 2007). The construction industry is characterized by high rates of work-related accidents (Arndt *et al.,* 2005), and deliverables in little time (Campbell, 2006). It also has characteristics of "hire and fire" and "part-time jobs," making unemployment predominant, all which constitute to be stressors of mental health (Beswick *et al*., 2007). Mental health (MH) refers to the condition of mind, state of wellbeing, composure in behavior, and actions to persons and the environment in a positive manner (WHO, 2004).

While good MH (psychological health) can be summarised as a positive state of mind influencing positive responses to events and environment, mental ill health (poor MH) can be viewed as a shortcoming in MH. Mental ill health affects the perception, reaction, and attitude of an individual to things, stress, and the environment (Australian Government Department of Health (AGAC) 2007). Common mental ill health problems include distress, depression, and anxiety (Risal, 2011). Among working populations, such poor MH can affect productivity, performance, safety, physical health, and well-being (Rajgopal, 2010).

Construction project work is dynamic and uncertain, elevating the industry's stressful nature (Bowen *et al*., 2013a). Low participation regarding decision-making roles and low support are also stressors rampant in the industry (Boschman *et al*., 2013). These stressors constitute psychosocial factors causing mental distress which in turn results into mental ill health such as stress disorder, anxiety, depression, and suicide ideation among construction personnel (Burki, 2018; Boschman *et al*., 2013). Burki (2018) indicated that between the year 2011 and 2015, 1419 construction workers in England committed suicide, leaving death by suicide, especially amongst low-skilled workers at 3.7 times above the national average. In Australia, such death was two times the nation's average population (Gullestrup *et al*., 2011; Heller *et al*., 2007). In 2012, the suicide rate in the construction industry of the United States of America was 4.25 times above the national average per 100,000 population (McIntosh *et al*., 2016). Globally, the industry has higher rates of suicide due to psychosocial factors causing stress, anxiety, depression, and suicidality (Bryson and Duncan, 2018; Milner *et al*., 2014).

Mental ill health remains a global burden (Selamu and Singhe, 2017) and not restricted to a particular race, culture, society, or status quo (WHO, 2013). It leads to lost work hours and considerable costs to employers and nations (PwC, 2014; WHO 2003). Within the UK construction industry, the estimated work hours lost per year due to MH problems is 400,000 hours. Across all sectors in Australia, efforts to reduce mental ill health yielded a saving of 2.30AUD for every one AUD invested into MH in the workplace, as the loss of work hours and workers' compensation claims due to mental distress reduced by 33% (see PwC, 2014).

However, workplace MH-related studies in general and particularly in the construction industry are still at an elementary stage (Burki, 2018). In order to curb such losses and ensure a healthier, safer workplace, the industry is particularly eager to address MH issues (Burki. 2018). Thus, it is essential to review the state of MH research in the construction industry.

Knowledge gap, aim, and objectives

There have been several reviews on workplace MH research (Memish *et al*., 2017; Farmer, 2017; Roche *et al*., 2016; Tsutsumi, 2011; Alberta Health Service, 2010). However, only a few focused on the construction industry. For instance, Roche *et al*. (2016) conducted a review of depression in male-dominated occupations; while Alberta Health Service (2010) reviewed addiction and MH in the construction industry. Although these reviews were quantitative, none visualized the body of knowledge. Additionally, none applied science mapping to analyze and build maps to explain how the occupation-specific MH field of research is structured intellectually and socially.

Therefore, the present study uses the science mapping method to quantitatively analyze and visualize the global research on MH in the construction industry, with the following objectives: (i) to identify institutions (affiliations) and countries who are research frontiers for collaboration possibilities; (ii) to identify current and emerging research areas; (iii) to identify significant documents and authors to consult in the research field.

Methodology

This study employed a science mapping unit of analysis, particularly co-author, co-word, co-citation analysis, bibliographic coupling, and clustering to achieve its objectives. This was conducted using science mapping software, CiteSpace 5.4.R1 (5) (64bit). Science mapping builds maps that outline the theoretical, intellectual structure, social structure, and the interrelationship between disciplines and research fields (Cobo *et al*., 2011). It uniquely presents a body of knowledge in a tangible form, through scientometric or bibliometric techniques (Chen *et al*., 2015). CiteSpace is one of the most widely used science mapping software (X. Li *et al.*, 2017). Science mapping using CiteSpace adopts several structural and temporal metrics (e.g., citation burst detection) in addition to the unit of analysis used to extract networks (Chen *et al*. 2010).

Unit of analysis

Co-author analysis probes authors and their connections to reveal their collaborative network (Cobo *et al.*, 2011). This is to identify research communities and frontiers (Olawumi and Chan, 2018). It is done by either analyzing influential co-authors and/or their institutions and countries. In this study, the co-authorship network was analyzed by considering participating institutions and countries. *Co-word (co-occurring keyword) analysis* reveals the conceptual structure of a research field (Cobo *et al*., 2011). *Co-citation analysis* reveals two articles that have been cited together by a third article (Chen *et al*., 2015). Based on co-citation analysis, two research papers are relevant only when they receive a citation from one or more citing papers (Habib and Afzal, 2019; Small, 1973). It illustrates the relationship between articles that form a primary dataset and corresponding articles cited by the first articles. This study performed author and documents co-citation analysis (i.e., ACA and DCA). Clustering is used to identify outstanding terms and context (Olawumi and Chan, 2018) and mostly referred to as cluster analysis.

Cluster analysis reveals the intellectual base and research front for each cluster. The prominent (cited) members form the intellectual base, while the citers are the research fronts of each cluster (Chen *et al*., 2012). In this study, the clusters were named using the Log-Likelihood Ratio (LLR). Usually, the software automatically labels the cluster using three algorithms, namely LLR, Latent Semantic index (LSI), and Mutual Information (MI). LSI indicates unknown semantic relationships in the document, while LLR and MI reflect a unique aspect or discussion of a cluster (Chen *et al*., 2010). The LLR label was considered because, unlike other algorithms, it generates clusters of high quality with high intra-class and low inter-class similarity (Olawumi and Chan, 2018). LLR ensures that terms which are grouped within a category related to each other and different from those in other categories.

Bibliographic coupling reveals related documents by analyzing references of cited papers (Habib and Afzal, 2019). In bibliographic coupling, two research articles are related if both articles cite one or more papers in common (Habib and Afzal, 2019), unlike in co-citation analysis where two articles are relevant to a study only if a third document has cited them (Merigo *et al*., 2019; Small, 1973). While co-citation analysis can reveal documents from another field of study relevant to the particular research field, the bibliographic coupling would only inform documents within the field of research under investigation. Both co-citation and bibliographic coupling are employed in science mapping studies to ensure a comprehensive review (see Habib and Afzal, 2019; Merigo *et al*., 2019).

Metrics

Structural metrics adopted by CiteSpace and relevant to this study include betweenness centrality, modularity, and silhouette, while temporal metrics include citation burst. *Centrality* gives information about structural holes, gaps which can be followed by research (Chen, 2016). It indicates where useful information, concepts, ideas can be seen. Though, centrality can be measured using four metrics; closeness, betweenness, degree, and page-rank (Yan and Ding 2009), CiteSpace measures centrality using betweenness. Betweenness centrality reveals the degree to which a node under study functions as a coordinate of control in the network (Leydesdorff, 2007).

Modularity (Q), indicated by scores ranging from 0 to 1, describes the structural property of a network, as it assesses the degree to which a network can be subdivided into independent modules (Chen *et al*., 2010). It shows the degree of relatedness of the units that form a particular network. A low modularity score (Q) indicates that the structure cannot be decomposed into independent clusters, while high modularity signifies a well-structured cluster. Modularity also allows for comparison between different networks, for example, between the networks of ACA and DCA (Chen *et al.*, 2010).

Silhouette metric denoted by S indicates homogeneity of a cluster and ranges from -1 to 1. A network with mean silhouette value, 0.7 to 0.9 shows that the clusters are highly homogeneous as they contain documents related to each other. A cluster which is made up of closely related documents will have a high silhouette score and would be easier to label. On the other hand, a cluster with documents from different fields, such as those related to the method of analysis employed would have a lower silhouette.

Citation burst is a pointer to the most active participant, topic or area in a research field; it detects burst events. It also shows that a particular unit is linked to a surge of citations in the research field. It indicates that the unit under consideration attracted some degree of attention from its scientific community (Chen, 2014).

Method of data retrieval

The bibliographic data were retrieved from the ISI Web of Science (WoS) and Scopus because both databases contain the most influential peer-reviewed journals in any research field (Aghaei *et al.*, 2013). The relevant search string was arrived at after pre-analysis and comparison of search results. The following retrieval codes were employed using different combinations (see Table 1): "mental health" "psychological health" “depression” “anxiety” "psychological stress" "post-traumatic stress disorders" "construction industry." The retrieved documents were limited to journal articles, in the field of Construction, Engineering, Environmental science, and Psychology and written in the English language. As regards year of publication, the timespan for documents was set from year 1970 to 2018.

Insert Table 1

A total number of 197 and 69 articles were retrieved from Scopus and WoS respectively on 4th April 2019. The documents were scanned through for repetition and relevance in the research context by reading the titles and abstracts. Studies were excluded if they were in other fields, did not consider construction personnel, stress, and mental (psychological) health. Thereafter, only 110 and 35 articles were downloaded from Scopus and WoS, respectively. The articles from

Scopus were downloaded as RIS file while those from WoS as plain text (being a full record and cited references). The datasets were imported to CiteSpace as detailed by Chen (2014).

When using CiteSpace software for scientometric analysis, Scopus documents have to be converted into WoS format, out of which some information may get missing due to the format of the references. Such loss results from irregularities of the references cited, therefore achieving a 95% conversion rate is acceptable (Chen, 2014). In this process, the conversion rate for the 110 Scopus articles (having a total of 5812 references) was 99% (i.e., 5774 valid references). After the conversion process, both Scopus and WoS dataset were combined for the analysis. A total of 145 articles were utilized for the scientometric analysis. Though the number of publications retrieved were 145, they represent the global MH body of knowledge in the construction industry from 1974 to 2018 (see Fig. 1) and as such, scientometric techniques could be applied to map its intellectual structure and present same in visual form.

Insert Fig. 1 here

Parameter design on CiteSpace

When using CiteSpace, basic parameters that define the outcome of the result must be set. This analysis was conducted using the following settings. Time slicing was set at two years per slice for the entire period of 1970-2018. The timing slices ensures that two years are checked up together by the software, for instance, 1992 and 1993, 1994 and 1995 to generate a network visualization. Pruning was applied to the network analysis using pathfinder and sliced network. Pruning is a modeling technique which helps to eliminate redundant connections, retaining only essential networks.

The selection criteria were set at top 50 levels per slice for the most occurring or cited items. On the exclusion list was "Anonymous" as the node did not properly define an author or document. Merged networks were formed for authors whose names allowed for duplication of identity. For instance; Gatti U. C. and Gatti U., Leung M.Y., Leung MY. and Leung M-y., Bowen P. and Bowen PA., Lingard H., Lingard H. C., and Lingard were each merged to form one node. In such a case, one name formed the primary list while others made the secondary list.

Results and Discussion

Data retrieved were from the year 1974 to 2018. According to the search results, main empirical studies examining MH in the construction industry began in 1990 with one publication by van Vliet *et al.* (1990). Other pioneer studies which employed strong methodologies to examine MH in the construction industry include Triebig *et al.* (1992), Holmstrom *et al.* (1993) and Sutherland and Davidson (1993). van Vliet *et al.* (1990) and Triebig *et al.* (1992) examined symptoms of severe mental disorders (schizophrenia, psychosis, manic occurrences, and phobia) among construction tradesmen/artisans. The studies employed the International Classification of Disease (ICD) and Personal State Examination questionnaire, respectively. Sutherland and Davidson (1993) following a pilot study, examined common and severe mental disorders in construction professionals using the Crown-Crisp Experiential Index (CCEI).

Co-authorship analysis

Here the study analyzed research power network. The research power contained the network of co-authors' institutions and countries. It indicates the affiliations of influential authors in the MH field of research within the construction industry.

Research power network

In order to describe the distribution of publications in the MH research field within the construction industry, a network created by the participating institutions and countries based on co-authorship was generated. The network had 10 nodes and 10 links with modularity (Q) = 0.545, silhouette (S)

= 0.6147. The nodes signify ten (10) participating countries and institutions, while links 10 indicates cooperative connections and relationships between the authors' institutions in different countries. The Q value tells of average intercluster connections, while S value indicates that the members are consistent. Both the Q and S scores indicate that the nodes are densely packed (see Fig. 2).

Four (4) countries were identified with an immense scholarly contribution to the research area of MH in the construction industry. The countries are Australia, the United States of America (USA), People's Republic of China, and the Netherlands. Australia (citation count = 10; mean year 2015), USA (citation counts = 8; mean year 2011), China (citation counts = 4; mean year 2016) and Netherlands (citation counts = 2; mean year = 2013). The limited number of publications and participating countries indicate that MH research in the construction industry is still young and still gaining recognition.

This research power analysis signifies that Australian researchers are the most productive in this research field with an excellent collaborative relationship. Participating universities from Australia include Deakin University, RMIT University and the University of Melbourne. In the USA, participating institution includes Mt Sinai School of Medicine, with studies relating to post-traumatic stress disorders among responders (e.g., construction workers) of the World Trade Centre. In the Netherlands, participating institutions include the University of Arbouw and the University of Amsterdam. These institutions occupy a vital position in the body of MH research in the construction industry.

Insert Fig. 2 here

Citation burst and centrality

On centrality evaluation, the power network for the countries and institutions showed that only Australia and two Australian institutions had high betweenness centrality, indicated by the purple trims (see Fig. 2). Australia (centrality = 0.22) with citation burst (4.70, 2015-2018), University of Melbourne (centrality = 0.11) and Deakin University (centrality = 0.11). The centrality showed that Australia occupies a 22% position in the research power network, implying that Australia and its participating institutions occupy a strategic position in the field of MH within the construction industry. Citation burst indicates that Australian researchers have been active in this research area, maintained good collaboration association, and published at a fast rate.

Based on this study, it is essential to consult articles of authors from these countries, and institutions, particularly from Australian researchers, when researching into this field. Among the notable works of Australian researchers in this field are "mates in construction: impact of multimodal, community based program for suicide prevention" (Gullestrup *et al*., 2011), "promoting construction workers' health" (Lingard and Turner, 2017) and "smart-phone intervention to address mental health stigma in the construction industry: a two-arm randomized controlled trial" (Milner *et al*., 2018).

Topics and research trends in MH in the construction industry

This was evaluated using the co-occurring keyword network. Keywords indicate the soul of articles and can show at a glance the advancement in research topics.

The network of co-occurring keywords

The network had 142 nodes indicating the number of keywords and 114 links with Q = 0.681 and S = 0.3197 (see Fig. 3). Of all MH disorders, those indicated in the keyword analysis are post-traumatic stress disorders (2), stress disorders (3), depression (2), and suicide (7). Suicide had the highest citation counts. This could be because there are continued cases of suicide amongst construction workers owing to specific psychosocial factors (e.g., high job demand, work pressure or speed, low job control) in the profession (Burki, 2018; Milner *et al*., 2015).

Milner *et al*. (2015) asserted that the increased risk of suicide in the male-dominated industry resulted from psychosocial workplace and individual factors. The study opined that the risk factors alongside others resulted in increased poor MH and suicidality in the construction industry. For instance, work stress is a high-risk factor for depression (Tanışman *et al.*, 2014; Boschman *et al.*, 2013) and depression when left untreated is a top risk factor for suicide (WHO, 2017; H. Li *et al.*, 2017). A few studies reported cases of depression (see Langdon and Sawang, 2018; Sunindijo and Kamardeen, 2017; Boschman *et al*., 2013; Al-Maskari *et al*., 2011) and post-traumatic stress disorder among construction personnel (see Pietrzak *et al*., 2014a,b; Boschman *et al*., 2013).

The effort to mitigate stigma, depression and suicide among unemployed construction workers resulted in the development of a multimedia-based intervention called contact and connect (see Milner *et al.* 2018). The intervention is believed to mitigate mental ill health among construction workers when they are unemployed. Also, there is an increased call for MH research and interventions that are occupation specific. According to the analysis of the co-occurring keywords, keywords related to MH which have been trending in recent times (2016 to 2018) are related to health, psychosocial factors and research methods (see Table 2). These keywords reveal the current research direction for MH in the construction industry.

Insert Fig. 3 here

Insert Table 2 here

Citation burst and centrality

The keyword network yielded citation burst. The keywords with burst are article (burst strength = 7.04, 1992-2011), human (burst = 5.17, 1992-2008), male (burst = 4.85, 2007), and adult (burst = 3.99, 2011). Keywords with burst indicate that such words attracted great attention within a short time. The keywords analysis indicates that research into the health of male construction workers dominated the research area.

The analysis also yielded high betweenness centrality for seven (7) keywords namely construction industry (centrality = 0.30); human (centrality = 0.18); health (0.16), questionnaire (0.15), occupational risk (0.13), accident (0.11) and social support (0.11). The keywords with high betweenness centrality signify structural gaps where ideas are most likely to appear (Chen, 2016). The keywords with high centrality also received high citation counts. Thus, the keywords have determined the direction of this occupational MH research for years.

Co-citation analysis

This refers to the rate at which two different documents, articles, or journals are mentioned together by other articles or documents (Zhao, 2017; Song *et al*., 2016). It shows the level of importance of the co-cited documents; therefore, those documents are valuable articles to look-up in such field of research.

Author co-citation analysis

Author co-citation analysis (ACA) helps to reveal underlying specialties in a field of study, by identifying groups of authors cited together in literature (Chen, 2014). The unit of analysis consists of authors who have made an immense contribution to the discipline under review (Teng Chen, 2010). The ACA had 351 nodes, 440 links with 6859 references, Q value = 0.8470 and S value = 0.1062 (see Fig. 4). The node and font size of cited authors are proportional to the frequency of co-citation. From Fig. 4, it was seen that the top co-cited authors within the construction literature are Lingard (25), Leung (25), Bowen (19), Boschman (16), Love (15), Loosemore (14), Goldenhar (10), Petersen (8), Choudhry (8), Gatti (8) and Alavinia (8). Co-cited authors from other fields whose scholarly achievements have imparted the MH field in the construction industry include Karasek (23), Lazarus (15), Maslach (13), Frone (12) and Pallant (8),

Insert Fig. 4 here

Centrality and Citation burst

One co-cited author (Karasek) received a citation burst (burst strength = 7.62, 1993-2010). Robert Karasek job demand-control model has been pivotal to determining psychosocial workplace factors affecting the MH of construction industry personnel (i.e., professionals and frontline workers). High betweenness centrality was recorded for some co-cited authors, including those within and outside the construction industry, whose scholarly contributions have influenced the field of study (see Table 3). Top among them are Lazarus (centrality = 0.18), Boschman (centrality = 0.15) and Pallant (0.11). These three authors jointly occupy a pivotal position of 44% in the network. For instance, Richard Lazarus' stress theory has been very influential in the research field. Since most of the studies adopted the quantitative technique and analyzed data using the SPSS software, Julie Pallant received high centrality score because of reference to the SPSS survival manual.

Within the construction industry, Julitta Boschman studies on MH (i.e., Boschman *et al*., 2014, 2013) have been pivotal in this field of research; hence, the centrality score of 15% (i.e., 0.15). Thus, indicating that the documents of the authors represent a turning point in this field of research, as they are influential to the MH field of research in the construction industry. All authors with high citation counts had a centrality score. These authors occupy a pivotal position in this occupation-specific MH field of research, and therefore, it is necessary to consult articles of these authors when researching into the field.

Insert Table 3 here

Document co-citation network

The document co-citation helps to reveal the frequency at which the articles are cited. DCA is a useful forecasting tool, beaming light into future research path in the field under study while cluster analysis of the network helps researchers and other readers have an excellent summary of the players in each cluster (Song *et al*., 2016). The document co-citation network had 90 nodes, 145 links with Q equals 0.8417. The Q value indicates that cluster connections are divided into a loose couple. The analysis had an S value of 0.5178, which tells that the members are averagely consistent, with documents covering different but related subjects.

The top 12 most co-cited documents are Alavinia *et al.* (2009) (4 co-citations), Alavinia *et al.* (2007) (4), Gullestrup *et al.* (2011) (4), Lingard *et al.* (2010) (4), Love *et al.* (2011) (4), Welch (2009) (3), Mitropoulos and Memarian (2012) (3), Boschman *et al.* (2013) (3), Bowen *et al.* (2013a) (3), Soo *et al.* (2011) (3), Gatti *et al.* (2014) (3) and Berninger *et al.* (2010) (3) (see Fig. 5). These documents provide a good understanding of the state of MH research in the construction industry. Alavinia *et al.* (2009) evaluated the impact of several factors such as individual characteristics, work factors, lifestyle, and work ability on incessant sick leave permissions in the Dutch construction industry. The study suggested that to mitigate the occurrence of sickness amongst construction workers, preventive measures should be targeted at work ability, curbing smoking, and excessive physical load.

Bowen *et al*. (2014a) asserted that workplace psychosocial factors such as job demand, job control, and workplace support are risk factors for high-stress in the South African construction industry. The study revealed that exposure to such psychosocial factors and the resulting psychological stress differs with age and gender. Gullestrup *et al*. (2011) developed a suicide prevention intervention program for the construction industry of Australia. The intervention entails general awareness training on MH focusing on suicide prevention; suicide first aid, training of gatekeepers (volunteer connectors); training workers; providing suicide prevention hotline services and postvention support in the occurrence of suicide.

Insert Fig. 5 here

Citation burst and centrality

No document received citation burst, while betweenness centrality though low, was seen for some documents (see Table 4). The centrality score indicated that the documents represent some significant turning point, thus, influential to the MH field of research in the construction industry. For instance, Alavinia 2009 (centrality score = 0.02) indicates that Alavinia *et al.* (2009) occupies a single pivotal point of 2% in the network. Though some authors with citation counts did not have centrality scores, it is appropriate to consult all documents identified by this study when researching this field of MH.

Insert Table 4 here

Bibliographic coupling

Using bibliographic coupling, documents which have significantly impacted the field of MH research within the construction industry are summarized (see Fig. 6). Similar to other networks, the font size is proportionate to citation counts. Bibliographic coupling revealed that the top five most cited documents include: Gillen *et al.* (2002) (citation count = 245), Choudhry and Fang (2008) (citation count = 241), Siu *et al.* (2004) (220), Demerouti *et al.* (2010) (213), and Goldenhar *et al.* (2003) (126). The analysis also revealed that recent studies within the construction industry are leveraging on information technology (digital interventions) to prevent poor MH, improve health, well-being, and safety of construction personnel. They include Chen *et al.,* (2016, count = 21), J. Chen *et al*. (2017, citation count = 6), Guo *et al.* (2017, count = 10), Milner *et al*. (2018, count = 1), and Jebelli *et al*. (2018, count = 6). A citation count of zero signifies no record of the document in the references of all citing documents.

Insert Fig. 6 here

Cluster analysis

Author co-citation cluster (ACC)

For author co-citation analysis, only eight salient clusters were identified automatically by the software and named with ID #0, 1, 2, 3, 4, 5, 6, 7 (see Fig. 7). The cluster ID and name was based on the abstract terms of the co-cited authors that formed the cluster (see Table 5). All the clusters had silhouette 0.895-1.00, signifying they are highly homogeneous. On the other hand, the silhouette score suggests that each cluster is made up of adequately related members. Cluster #0 "safety-related stress," the largest cluster has 34 members while cluster #7 "labor exploitation" is the smallest cluster with seven members.

The timeline view was employed for cluster network visualization, as it gives details of the authors that form each cluster and the mean year of publication (see Fig. 7). Table 5 details the clusters, label by LLR and major citer(s) to the cluster. The intellectual base of a cluster is outlined by the cited members, while the citers are the core articles and known as the research fronts. A minimum of two citers are reported per cluster; the first citer was itemized based on percentage citations while the second citer, by gross citation score (GCS) or those whose title formed the cluster label. It is evident from Table 5 that cluster #2, 3, 4, 5, 7 with mean year ranging from 2014 to 2016 contain recent developments in the field of study. Only clusters with recent documents are explained to conserve space.

Insert Fig. 7 here

Cluster #2 was labeled "constructional professional" and has 21 members. Following label terms, it can be inferred that the cluster focused on "determinants of construction professionals' health." The top two citers to cluster #2 are Zacher *et al.* (2014) and Bowen *et al*. (2018), with 6% and 5% of all the citations, respectively (see Table 5). The most cited author was Peter E. D. Love. The cluster is made up of recent documents with mean year 2015. According to Cluster #2, determinants of MH are personal characteristics (such as age) and work-related characteristics (time pressure, job pressure, workload demand, work contact, work-family conflict). Zacher *et al.* (2014) found that the state of well-being is related to age differences in changeable work-related factors. Bowen *et al.* (2018) deduced that job control and job pressure predicted work-family conflict while work contact, work-family conflict, and job pressure determined psychological distress; with psychological distress predicting sleeping problems.

Cluster #3 was labeled "migrant on-site construction worker" and has 16 members. Based on the label terms, it can be inferred that the cluster focused on "psychological health and safety of construction tradesmen." Citers to the cluster include Wang *et al.* (2016) and Guo *et al.* (2017), with Rafiq F. Choudhry and Umberto C. Gatti as the most cited authors. Poor living conditions have been linked to poor MH (Fisher and Baum, 2010), even among migrant construction workers (see Al-Maskari *et al*., 2011). As part of the measures to address the living condition of construction workers, which is a social determinant of health, Wang *et al.* (2016) validated the possibility of utilizing prefabricated accommodations to improve the standard of living of migrants in the construction industry of South China.

Providing decent housing for migrant workers would solve the challenges of poor on-site living spaces, reduce physical and MH problems, and increase productivity (Wang *et al.*, 2016). Additionally, to ensure improved health of construction workers and their safety, Guo *et al.* (2017) proposed using wrist-worn wearable technology to gather the real-time mental status of construction workers and mental causes of construction accidents, to mitigate risky behaviors, thereby achieving good health and safety.

Cluster #4 was labeled "systems framework" and has 14 members. Based on the label terms, it can be inferred that the cluster focused on "mitigating mental and emotional stress." The major citers to the cluster include Dong *et al.* (2012) and Turner and Lingard (2016). Dong *et al.* (2012), utilizing the Centre for Epidemiologic Studies Depression (CES-D) scales to assess depressive symptoms, found that persistent back pain among construction workers was a risk factor for poor MH.

Cluster #5 was labeled "work ability" and had 12 members. Citers to the cluster include Hengel *et al.* (2013), Boschman *et al.* (2013, 2014). Boschman *et al*. (2013), employing several validated scales examined the prevalence of MH among bricklayers and supervisors. The study found a prevalence of fatigue and depression among construction workers. Thereafter, Boschman and colleagues examined the effect of common mental disorders (such as depression) on work ability among bricklayers and supervisors and reported that irrespective of occupation, workers had a high incidence of low work ability (see Boschman *et al.* 2014).

Cluster #7 was labeled "labor exploitation," it has nine members and a silhouette of 1. The silhouette indicates a perfect solution, signifying that the members discussed the same topic. Based on the label terms, it can be inferred that the cluster focused on "stressors of MH among construction frontline workers" Major citers include Langdon and Sawang (2018), Turner-Moss *et al.* (2014), and Jebelli *et al.* (2018). The cluster is made up of recent documents with mean year 2016. Jebelli *et al.* (2018) proposed a signal processing framework for monitoring construction worker's brain waves to assess psychosocial stressors. According to the citers, the stressors of MH include unsafe working and living conditions (Turner-Moss *et al.* 2014), and lack of personal time and finances (Langdon and Sawang, 2018).

Insert Table 5 here

Keyword co-citation clusters (KCC)

Keyword clusters were used to determine noteworthy keywords. Such keywords were clustered into nine (9) categories and had a silhouette between 0.845 and 0.99 (see Table 6). The two largest clusters are cluster #0 "workplace injury" with 36 members, mean year 2005 and cluster #1 "poor mental health" with 23 members and mean year 2013. It is evident from Fig. 8 and Table 6 that Cluster #3 and #8 with mean year 2014 and 2016 respectively contained recent developments in the field of study. In order to conserve space, only clusters #3 and #8 are discussed.

Cluster #3 was labeled "cognitive test," with significant citers as Chen *et al.* (2016) and Larsson *et al.* (2008). Chen *et al.* (2016), using EEG data developed a measurement framework to monitor the mental condition of construction workers objectively, so as to improve health and safety. Cluster #8 was labeled "safety behavior," with significant citers as Leung *et al.* (2015) and Y. Chen *et al.* (2017). Leung *et al.* (2015) developed a stressor-stress-safety behavior-accidents model. The study assessed measures for preventing injuries among construction workers by investigating the role of work stressors, physical and psychological stress on safety behavior and accidents. According to the study, psychological stress was predicted by concerns about the job (job uncertainty and job insecurity) and supervisor support. Following the cluster labels and content, both clusters #3 and 8 are related to "psychological health and safety behavior."

Insert Fig. 8 here

Directions for future research

Attention to the theme identified by the cluster analysis will inform on research efforts to achieve sustainable MH interventions in the construction workplace. Recent themes related to psychological health and safety among tradesmen, determinants of physical and mental health among construction personnel, mitigating mental and emotional stress, and work ability. The study revealed that future studies should focus on measures that pertain to improved working conditions, physiological responses to workplace stressors, physical and mental health awareness, and organizational justice. Based on the findings of the study, the following directions for future research are proposed:

MH of construction tradesmen

The review revealed that research into stress, coping, and MH outcomes in the industry had focused more on construction professionals. What has dominated the literature for construction tradesmen pertains to stress, its impact on workplace safety and productivity. There is a need for increased research into the MH of construction front line workers (Langdon and Sawang, 2018), as these group of workers engages in repetitive, tedious jobs resulting into musculoskeletal disorder, stress-related disorder and depression (Boschman *et al*., 2013). Therefore, the target population for future studies should be all-inclusive consisting of the project management team, on-site supervisory team, skilled and unskilled workers.

Studies examining the construction workplace risk factors have ignored the diversity in experiences within the industry (Boschman *et al.* 2013), as well as other contextual factors. Therefore, such studies into MH in the industry should consider conditions for specific trades and positions. This information would help to map MH risk, and protective factors specific to each trade, profession, and further enhance the development of appropriate primary and secondary job stress and MH interventions.

Methodologically robust studies on protective factors

Studies to determine protective factors for MH in the construction industry must be intensified to enable the achievement of sustainable MH interventions. The review showed that studies in the construction industry are focused on risk factors for mental ill-health, while protective factors for good MH are less researched. Psychosocial risk factors deduced by studies on work stress and MH of construction personnel (Bowen *et al*., 2018; Langdon and Sawang, 2018; Leung *et al.*, 2015; Bowen *et al*., 2013a, 2014; Lingard *et al*., 2012) are mostly related to stressors such as work conditions, low job control, little job support, high job demand, organisational injustice (i.e., gender, age discrimination, harassment), conflict and interpersonal relationship, social economic status (i.e., low income, job insecurity) and physical illnesses.

On the other hand, protective factors act as a catalyst, making a difference in the influence of a risk factor (Rutter, 1985); they include personal resources (such as resilience, hope, self-efficacy), coping strategies, social resources (social support) and motivation (see McDowell *et al.*, 2019; Wille *et al.*, 2008; Werner and Smith, 1992). Protective factors researched in the construction industry are mostly a reverse of risk factors with no strong methodological principles used to achieve them. Though there have been studies into stress-coping strategies, most of which did not link coping strategies to MH. For instance, coping strategies have been found to have varying mediator effect on mental ill health (see Langdon and Sawang, 2018; Sunindijo and Kamardeen, 2017; Love *et al*., 2010). Protective factors should not only mirror risk factors, as that would lead to defective interventions (see Franklin *et al*., 2017). Studies into protective factors should follow appropriate theoretical and methodological distinction from risk factors (Wille *et al*., 2008).

Therefore, there is a need for studies into MH of construction personnel to examine both personal resources, coping strategies, and their influence on MH. This would assist the industry in arriving at sustainable MH interventions. A comprehensive study of risk and protective factors will provide an appropriate basis for developing primary and secondary interventions (McDowell *et al*., 2019; Wille *et al*., 2008). This implies that more comprehensive studies designed to evaluate both risk and protective factors are needed as risk factors do not occur in isolation, but rather cluster together and interact with one another; they may also vary with age, gender and time of exposure. Therefore, it is expedient to identify factors that modify such risk in order to focus them in preventive interventions. Such studies would also benefit from examining the interaction between the risk factors, protective factors, and mental ill health.

Organizational justice

Research into work stress (e.g., Sunindijo and Kamardeen, 2017; Bowen *et al*., 2013b; Love *et al*., 2010) and job satisfaction have come a long way, however, psychological ill health due to work stress is still seen to be prevalent amongst construction personnel (Langdon and Sawang, 2018; Sunindijo and Kamardeen, 2017). There is, thus, the continual need for studies into job satisfaction and MH of construction personnel. Such studies should examine practices of organizational injustice centered around age, gender discrimination, and harassment.

For instance, Bowen *et al.* (2013b) found that gender and age are determinants of mental distress, pointing to discrimination in the construction workplace. The study also emphasized a high turnover in the industry and the need for mechanisms to combat them. Work stress, such as high job demand, low job control, little job support, bullying, harassment and gender discrimination impacting on MH, are significant causes for early exit and refusal to entry by female construction professionals (Kamardeen and Sunindijo 2017; Sunindijo and Kamardeen, 2017).

This calls for MH interventions and policies in the construction workplace that will promote organizational justice, as organizational justice fosters job satisfaction, reduces burnout and sleep problems (Topbaş *et al.*, 2019; Gluschkoff *et al.*, 2017).

Flexible work systems

Work satisfaction and improved individuality can be increased through flexible work system (Kwon, 2019). More research accompanied by enforceable policies built around employee satisfaction measures is needed across varying cultures, nationalities, age group, and gender. This is because employee or job satisfaction has been linked with MH (Appleton *et al.*, 1998). In order to achieve job satisfaction and MH in this technological age, there is need for more researches into Flexible Work Systems (FWS) such as Result-Only Work Environment (ROWE), flexi-term contract, self-scheduling, and flexitime intervention (see Joyce *et al.*, 2010; Ressler and Thompson, 2008; Kelly and Moen, 2007) among construction industry personnel.

In the construction industry, Lingard *et al.* (2007) evaluated compressed work week (CWW) among construction tradesmen. CWW is a type of self-scheduling flexible work system aimed at improving employee's work-life balance with potential benefit on MH. However, the overall impact of such CWW on MH was not appropriately quantified, as no validated MH scale was used to assess MH at post-intervention. Studies into FWS in the construction industry should measure the effect of FWS on MH (Joyce *et al.*, 2010). According to the study, irrespective of the intended primary and secondary outcome in a job stress study, MH should be accessed.

In an intervention study, it is expedient that both primary and secondary outcome be measured using a validated instrument at pre and post-intervention, to quantify the effect on MH.

Therefore, studies into FWS and its impact on mental and physical health in the industry are needed. Presently, most studies on MH in the industry are dominated by developed and emerging countries. There is a dearth in research as regarding FWS and MH of construction personnel in developing and low-income economies. More studies into FWS could help inform appropriate FWS for varying culture and workgroup context.

Culture and context-specific studies

All-purpose and all-culture interventions are not efficient (Rebar and Taylor, 2017). Therefore, MH interventions in the construction industry that are unique to varying cultures, race, and age could be helpful. First, cross-cultural research in the field of MH within the construction industry could help promote the knowledge of MH, strengthen management principles, and modify interventions in the industry. Cross-cultural studies help to generate new knowledge and facilitate the development of cultural-specific MH interventions (Liu *et al*., 2018).

Secondly, a means to achieve such interventions could be through the development of psychological self-reporting scales that are peculiar to the construction industry and unique to the different type of firms and economies. For instance, following a result inconsistent with previous studies, Langdon and Sawang (2018) suggested that the respondents in their study may not have understood the wordings of certain constructs in the Brief Coping Inventory (BCI) scale.

The BCI's acceptance coping question "accepting this has happened" and "learning to live with it" may indicate negative coping style and not a positive coping mechanism (see Langdon and Sawang, 2018). Finally, owing to the number of publications in the MH field of research within the construction industry, there is a need for intensified research and published articles in the area, which would, in turn, assist in ensuring psychologically healthy and productive personnel, and a safer workplace.

Limitations

A limitation of this study is the number of published articles used for the study. This number can be traced to the field of research being young. However, the scientometric analysis highlighted research efforts in this body of knowledge. Additionally, when merging the cells of authors with varying initials, only eligible nodes could be merged to form a primary and secondary node. Irrespective of this limitation, the quality of the analysis was maintained.

Conclusion

MH research in the construction industry is gaining attention, although this study reveals it is still at an embryonic stage. This study provides a scientometric review by science mapping the body of knowledge of MH in the construction industry. A total of 145 bibliographic records were retrieved from the core collection database of WoS and Scopus. Using CiteSpace, the science mapping techniques were employed to assess the state and direction of MH research in the construction industry.

Co-authorship analysis revealed that Australian researchers had the best collaborative network, making Australia the most influential research power in the research field. Co-word analysis revealed that subject topics (keywords) in the research area had been related to physical and mental health conditions, psychosocial health stressors, subjective data collection, and analytical methods. However, the study deduced that research directions in this field have moved towards using digital interventions for preventing poor MH and objectively evaluating mental stress, which could cause fatigue and mental ill health.

Recent themes according to co-citation analysis related to psychological health and safety among tradesmen, determinants of health among construction personnel, mitigating mental and emotional stress, and work ability. It is concluded that intelligent measures to mitigate the negative effect of job demand in the construction industry are sought as research have moved towards objective means of data collection and real-time monitoring of workers (i.e., using heart rate, and HRV metrics) to ensure improved health and safety. Measures that promote organizational justice, flexible work systems, MH protective factors should be part of workplace MH promotion, and intervention strategies, this would provide appropriate primary and secondary interventions necessary to prevent MH problems.

The information in this review provides researchers and policymakers a one-stop-shop to foundational articles needed when researching into this field. It also provides a hint on potential collaboration channels. It serves as a quick map to young researchers, beaming light on authors whose articles should be consulted and specific primary articles for study in this field while pointing at research directions.

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Table 1. Article search string

Database	Search string combination
Scopus	(“mental health” OR “psychological health” OR depression OR “mental disorder” OR “mental stress” OR anxiety OR “psychological stress” OR “post-traumatic stress disorders” OR ptsd OR psychological OR mental) AND (“construction industry” OR “construction workers” OR “building industry” OR “construction professionals”)
WoS	“mental health*” AND “construction industry*” OR “psychological health*” AND “construction industry*” OR “psychological stress*” AND “construction professionals*” OR “mental stress*” AND “construction industry*” OR “psychological stress*” AND “construction workers*” OR “mental health*” AND “construction workers*” OR “mental health*” AND “construction professional*”

Table 2. Some co-occurring keywords between 2016 and 2018

Co-occurring keywords	Citation counts	Co-occurring keywords	Citation counts
Health-related		Psychosocial related	
Work stress	3	Accident prevention	8
Mental stress	3	Injury	4
Depression	2	Organizational justice	2
Fatigue	2	Mental workload	2
Emotional exhaustion	2	Job demand	2
Psychological condition	2	Family conflict	2
Subjective data related		Working condition	2
Questionnaire	19	Objective data related	
Structural equation modelling	9	Electroencephalography (EEG)	4
System dynamics	2	Frequency band	2
Factor analysis	2	Heart rate variability (HRV)	2
Multivariant analysis	2	Physical examination	2

Table 3. Top 24 co-cited authors based on centrality score

Co-cited Authors	Citation count	Citation burst	Betweenness centrality
Construction			
Boschman Julitta S	16		0.15
Leung Mei-Yung	25		0.07
Choudhry Rafiq M.	8		0.07
Djebarni Ramdane	7		0.07
Mearns Kathryn	3		0.06
Lingard Helen	32		0.05
Gatti Umberto C.	8		0.05
Bowen Paul	19		0.04
Loosemore Martin	14		0.04
Goldenhar Linda M.	10		0.04
Alavinia Seyed M.	8		0.04
Xiong Bo	3		0.04
Tam Vivian W. Y.	3		0.04
Love Peter E. D.	15		0.03
Other fields			
Lazarus Richard S	15		0.18
Pallant Julie	8		0.11
Brenner Harold	5		0.08
Maslach Christina	13		0.07
Hair Joseph F.	8		0.07
Karasek Robert	23	7.62	0.05
Spector Paul E.	7		0.05
Hobfoll Stevan E.	8		0.04
Burke Ronald J.	3		0.04
Nunnally Jum C.	4		0.03

Table 4. Top 10 co-cited document based on CiteSpace, citation counts, centrality and mean year

Co-cited documents	Citation counts	Centrality	Year	Source journals	Volume	Page
Alavinia S. M.	4	0.02	2007	Scandinavian Journal of Work Environment Health	33	351
Alavinia S. M.	4	0.02	2009	Scandinavian Journal of Work Environment Health	35	325
Wu X.	2	0.02	2015	Accident Analysis and Prevention	78	58-72
Leung M.	2	0.02	2015	Book Chapter	0	0
Hayes A. F.	3	0.01	2012	Book	0	0
Samuel O. B.	2	0.01	2015	Management	5	96-106
Lu W.	2	0.01	2011	Automation in Construction	20	101-106
Han S.	2	0.01	2013	Automation in Construction	35	131-141
Bowen P.	2	0.01	2014	International Journal of Project Management	32	1273-1284
Boschman J. S.	2	0.01	2013	American Journal Industrial Medicine	44	748-755

Table 5. The top 8 salient co-cited authors clusters and major citers

Cluster	Size	Silhouette	Mean year	Cluster label	Key Citer	GCS
#0	34	0.895	2011	Safety-related stress	(15%) Bowen *et al.* (2014b) (4%) Love *et al.* (2010)	13 52
#1	32	0.959	2012	Safety awareness	(14%) Kao *et al.* (2016) (5%) Larsson *et al.* (2008)	11 67
#2	21	0.947	2015	Construction professional	(6%) Zacher *et al.* (2014) (5%) Bowen *et al.* (2018)	22 3
#3	16	0.956	2016	Migrant on-site construction worker	(6%) Wang *et al.* (2016) (3%) Guo *et al.* (2017)	10 10
#4	14	0.903	2014	Systems framework	(9%) Dong *et al.* (2012) (6%) Turner and Lingard (2016)	10 0
#5	12	0.95	2014	Work ability	(5%) Hengel *et al.* (2013) (5%) Boschman *et al.* (2013)	16 26
#6	11	0.958	2013	Social-ecological perspective	(6%) Lingard and Turner 2015 (9%) Dong *et al.* (2012)	12 10
#7	9	1	2016	Labour exploitation	(2%) Langdon and Sawang (2018) (2%) Turner-Moss *et al.* (2014) (1%) Jebelli *et al.* (2018)	2 26 6

Note: Details of the key citers, other citers and cited document to each cluster can be found at http://dx.doi.org/10.17632/xgv997gypy.1

Table 6. The top 9 salient co-cited keyword clusters and major citers

Cluster	Size	Silhouette	Mean year	Cluster label	Key Citer	GCS
#0	36	0.876	2005	Workplace injury	(8%) Wu *et al*. (2016) (3%) Gillen *et al*. (2002)	5 245
#1	23	0.845	2013	Poor mental health	(7%) Zhang *et al*. (2016) (5%) Love *et al*. (2010)	15 52
#2	19	0.909	2007	Occupational stress	(6%) Dainty *et al.* (2004) (4%) Siu *et al.* (2004)	21 220
#3	15	0.953	2014	Cognitive test	(6%) Chen *et al.* (2016) (2%) Larsson *et al.* (2008)	21 67
#4	9	0.928	2012	WTC responder	(7%) Pietrzak *et al.* (2014a) (8%) Pietrzak *et al.* (2014b)	27 91
#5	8	0.963	2012	Developed system	(6%) Wang *et al.* (2016) (1%) Demerouti *et al.* (2010)	10 213
#7	7	0.955	2006	Work efficiency	(5%) Lingard and Turner (2015) (1%) Choudhry and Fang (2008)	12 241
#8	5	0.99	2016	Safety behavior	(3%) Leung *et al*. (2016) (1%) Y. Chen *et al.* (2017)	27 21
#9	4	0.966	2006	Healthy eating	(3%) Lingard and Turner (2015) (1%) Dong *et al.* (2012)	12 10

Note: Details of the key citers, other citers and cited document to each cluster can be found at http://dx.doi.org/10.17632/xgv997gypy.1

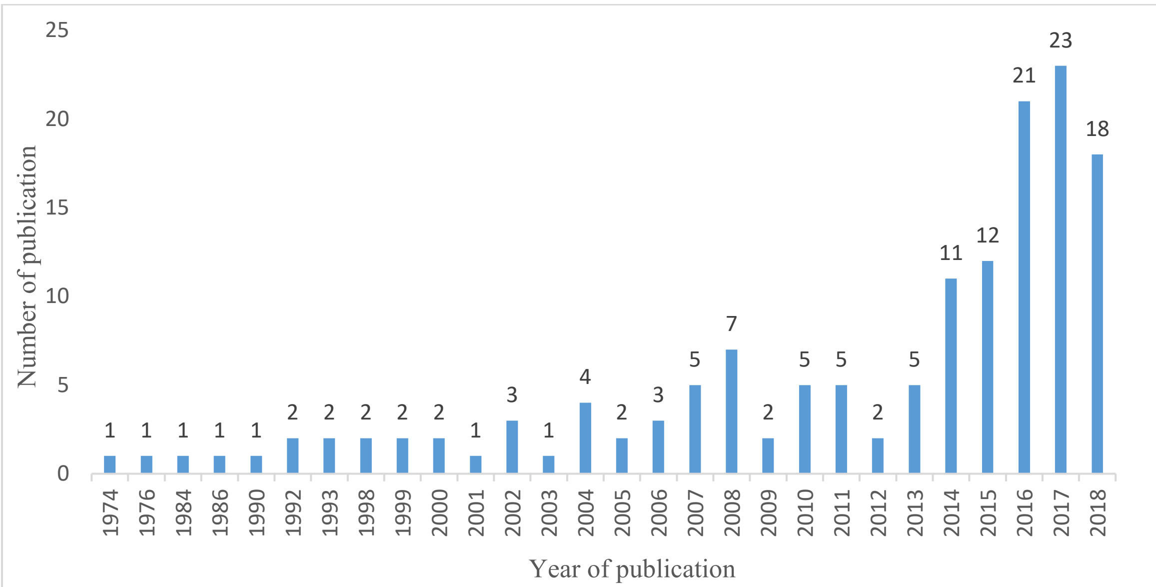

Fig. 1. The annual distribution of MH in construction industry articles from 1993-2018.

Fig 2. The network of research power

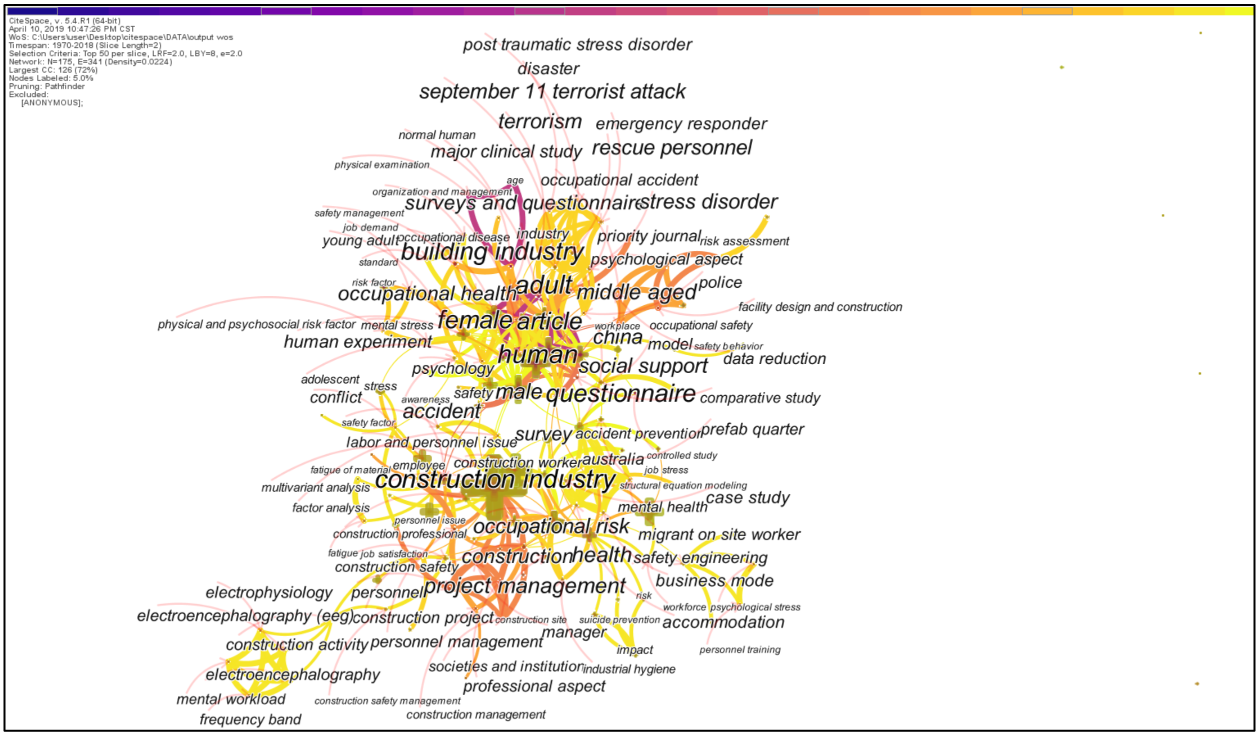

Fig 3. The network of co-occurring keywords

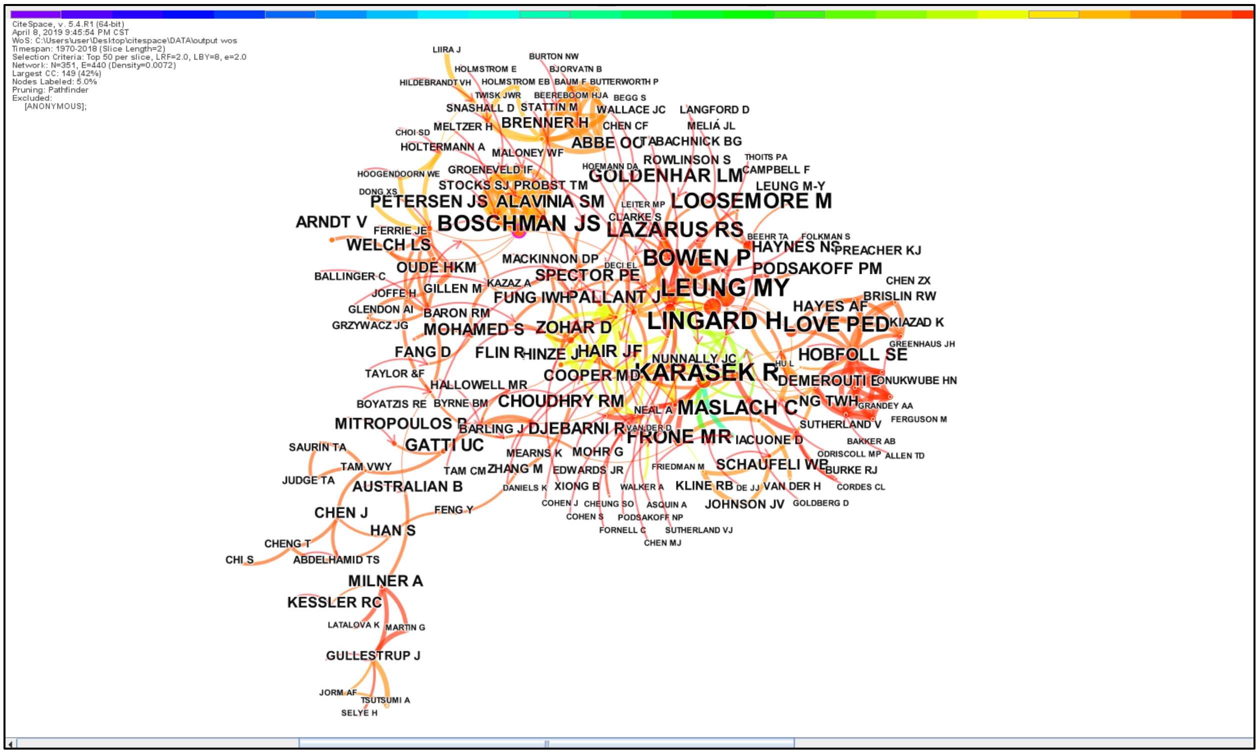

Fig. 4. The network of co-cited authors

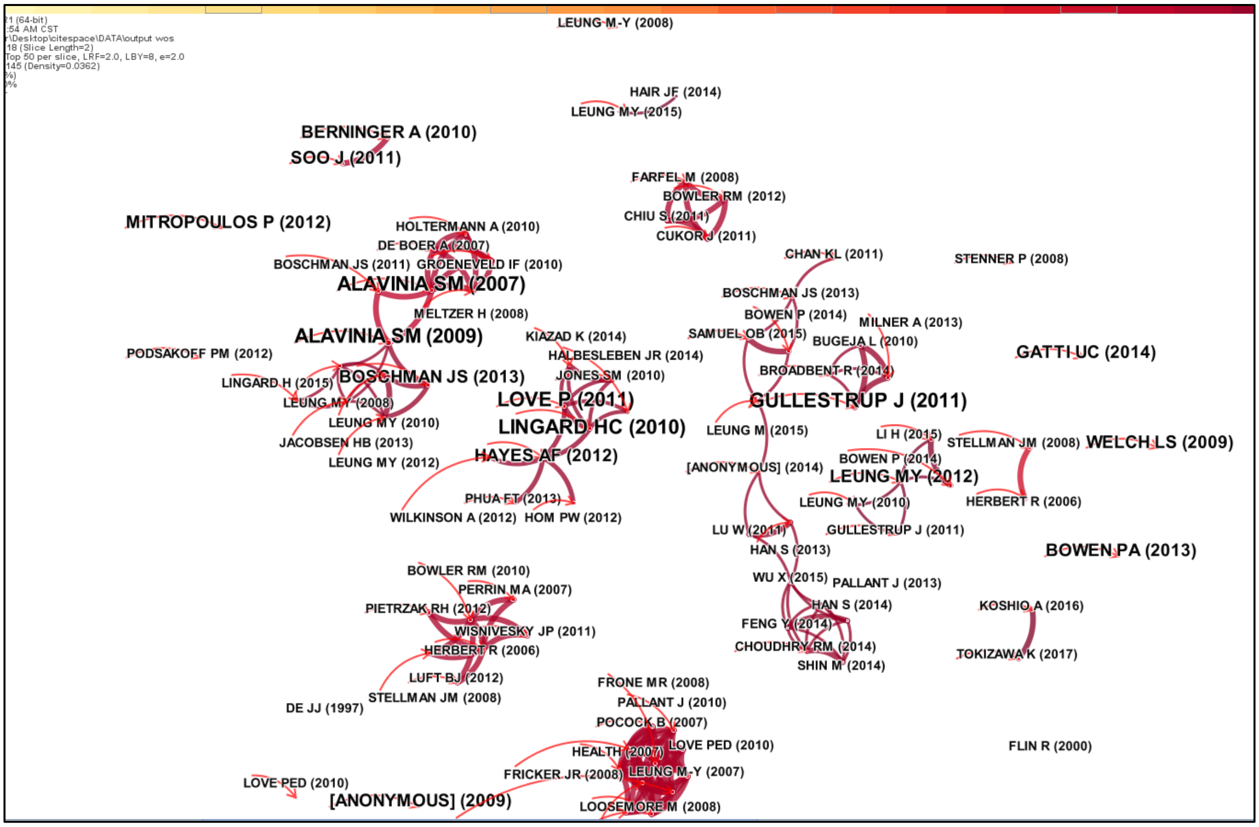

Fig. 5. Document co-citation network

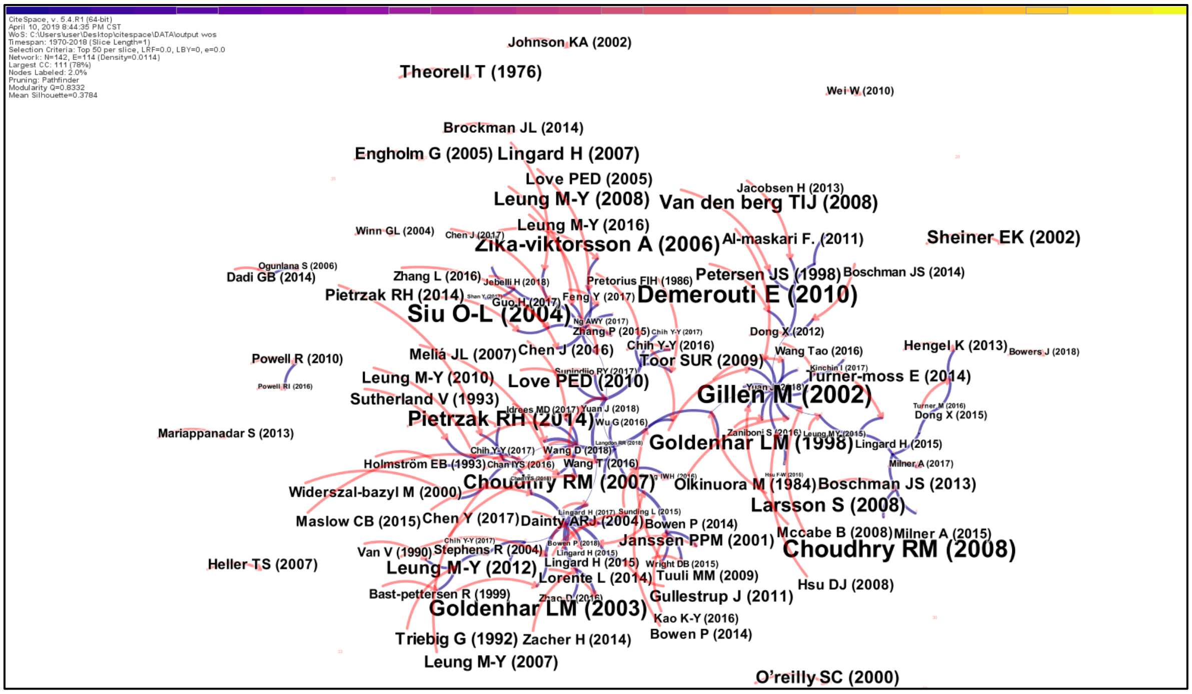

Fig. 6. Influential documents based on bibliographic coupling

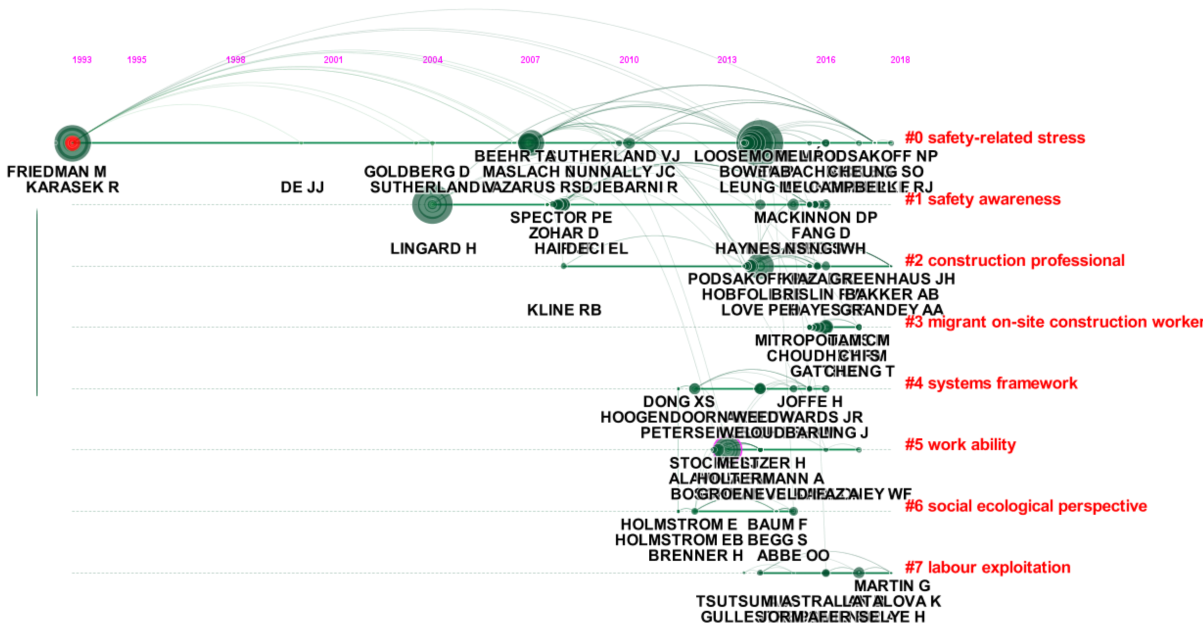

Fig. 7. Timeline view of author co-citation clusters

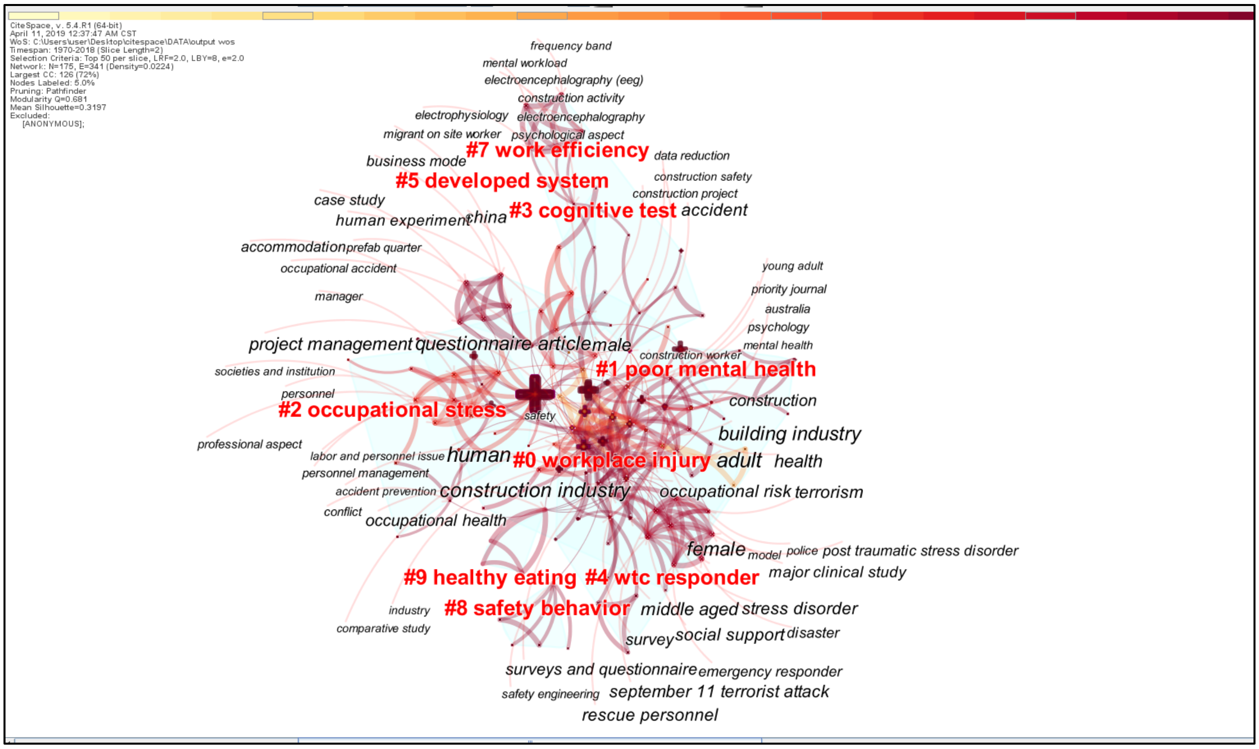

Fig. 8. Keywords co-citation clusters