Safe Behaviour in The Petrochemical Industry: Evaluating The Consistency Between Conceptual Frameworks and Factors Reported by Iranian Workers

Azita Zahiri Harsini
Tarbiat Modares University Faculty of Medical Sciences
Philip Bohle
University of Tasmania Tasmanian School of Business and Economics
Lynda R Matthews
The University of Sydney School of Faculty of Medicine and Health
Fazlollah Ghofranipour
Tarbiat Modares University Faculty of Medical Sciences
Hormoz Sanaeinasab
Baqiyatallah University of Medical Sciences
Farkhondeh Amin Shokravi (aminsh_f@modares.ac.ir)
Tarbiat Modares University https://orcid.org/0000-0001-7013-0167
Krishan Prasad
Western Sydney University School of Business

Research

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Abstract

Background: Unsafe worker behaviour is often identified as a major cause of dangerous incidents in the petrochemical industry. Behavioural safety models provide frameworks that may help to prevent such incidents by identifying factors promoting safe or unsafe behaviour. A literature review was conducted to identify models of safe behaviour and determine which were most consistent with the experiences reported by workers in our qualitative study of the Iranian petrochemical industry.

Methods: Five databases (EBSCOhost, Google Scholar, ProQuest, Science Direct, Scopus) were searched for studies between 2000 and 2019 that evaluated antecedents and outcomes of safe workplace behaviours in the petrochemical industry or other industrial settings. After duplications were removed, 141 publications were screened and 31 that met the inclusion criteria were reviewed. Constructs described in each publication were assessed for consistency with themes derived from the interview responses from Iranian petrochemical workers in the qualitative study: *poor direct safety management and supervision; unsafe workplace conditions; workers' perceptions, skills and training;* and *broader organisational factors*.

Results: The themes identified in the qualitative study most closely matched those in the model described by Wu et al. (2011): *poor direct safety management and supervision* matched with *safety leadership* and several subscales; *unsafe workplace conditions* matched with several subscales; *workers' perceptions, skills and training* matched with two subscales, and *broader organisational factors* matched with two other subscales. The model selected was the one that included the most constructs matching the themes identified in the qualitative study.

Conclusions: Valid behavioural safety models can provide a basis for more effective safety cultures and management systems in selected contexts. This study identified most consistency between themes elicited from Iranian petrochemical workers and the constructs described by Wu et al. (2011), providing evidence of the validity of their model. Intervention studies are needed to assess the effectiveness of safety models in improving safe behaviours in industrial settings.

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Background

The International Labour Organization (ILO) estimates that one worker in the world dies every 15 seconds because of occupational injuries, and 160 workers suffer work-related illnesses [1, 2]. Workplace accidents not only cause occupational injuries and illness, but also lead to financial losses for organisations [3]. Most behaviour-based safety researchers consider that dangerous incidents are principally caused by workers acting unsafely or inappropriately and many studies have focused on worker behaviours that promote safety and prevent injuries [4]. Workplace safety is not solely explained by human error, however, and many other factors may contribute [5].

A substantial body of research indicates that organizational factors, including managers' behaviour and decisions, have a significant impact on safety-related attitudes and behaviours in industrial contexts [6]. Several studies, for example, indicate that safety performance is affected by leadership [6–8]. There is evidence that leadership and effective occupational health and safety management, particularly by direct managers and supervisors, are necessary to promote safe behaviour [9, 10]. Hald [11] noted that the role of leaders and managers typically involves various functions, such as setting goals and monitoring and controlling workers' performance. Other evidence indicates that broader organisational variables, such as work intensification arising from increases in expected output or extended working hours, are associated with poorer safety outcomes [12, 13].

Another organisational factor is the contextual impact of safety climate [14, 15]. Several studies have found a significant positive relationship between safety climate and safe behaviour [16–18]. Safety climate is usually regarded as a subset of organizational climate that shapes workers' behaviour through a coherent set of perceptions and expectations about an organization's values and reward systems [19, 20]. Various studies indicate that a poor safety climate leads to a reduction in compliance with safety procedures which, in turn, causes an increase in the potential for workplace injuries and incidents [7, 21–23].

Reason (2000) describes two different ways to understand human errors at work: the individual ('person') approach and the system approach. The first approach focusses on unsafe acts by workers, inappropriate ways of doing tasks that could result in a dangerous incident – for example, lack of, or inappropriate use of, personal protective equipment (PPE); operating equipment without qualification or authorization; or operating equipment at unsafe speeds [24]. The second approach focusses on unsafe working conditions, or the state of the workplace system that could result in a workplace accident. Examples include defective tools, equipment or supplies, lack of emergency exits, and inadequate warning systems. Recent studies have placed importance on psychosocial conditions in policy, and demonstrated the value of workers' psychological wellbeing at work. Organisations which aim to concentrate on both physical and psychological factors together have safer working environments at lower risk of employee mental and physical health harm, and in consequence, lead to the positive workplace behaviours like work engagement and safety incident reporting [25].

Many safe behaviour studies have been based upon various generic safety theories and models, such as the Health Belief Model (HBM) [26–29], the Theory of Planned Behaviour (TPB) [30–33], the Risk Perception Attitude (RPA) Framework [34–36], and Social Cognitive Theory (SCT) [37–39]. There is also a growing recent literature supporting the positive effects of safety behaviour interventions on safety compliance and participation, injury rates, and near-misses in various high-risk industries, including the oil, gas and petrochemicals industry [40–42].

A recent study by this research team [43] identified four factors that workers believe discourage safe behaviours in an Iranian petrochemical company: 1) poor direct safety management and supervision, 2) unsafe workplace conditions, 3) workers' perceptions, skills and training, and 4) broader organisational factors. The aims of the current study are to conduct a literature review to identify theoretical models that have been proposed to explain and predict safe behaviour in the workplace between 2000 and 2019 and then select the model that best reflects our findings and other evidence on the factors influencing safe behaviours among petrochemical workers.

Methods

Qualitative Data Analysis

The interviews were conducted between May and July 2017 at mutually convenient time and private areas at the participants' workplaces. To obtain a broad cross-section of worker opinions and experiences, multi-stage sampling was used. This approach involves a combination of two or more sampling techniques. By combining sampling methods at different stages of research, researchers can increase confidence that they are mitigating biases and engaging hard-to-reach, vulnerable participants [44]. In this study, purposive sampling was supplemented by snowball sampling to enhance recruitment. Snowball and purposive sampling were selected because the research team considered the combination of the two was the most practical means to secure a representative sample of company employees.

Data saturation is reached when the final interviews do not reveal any new themes or introduce new elements of an existing theme. A total of 20 interviews were conducted before saturation was reached. The 20 participants included workers, supervisors and safety staff members.

For the analysis of responses from Iranian petrochemical workers [43], conventional content analysis, described by Graneheim and Lundman [45], was used to interpret the content of interview transcripts through a systematic classification process involving coding and identifying themes [46]. A team of six coders (four in Iran, two in Australia) reviewed the transcripts and conducted analysis in both languages. Open coding was carried out to allow codes to emerge from the qualitative data and avoid codes based on preconceptions of the authors. Codes were repeatedly discussed and revised by the authors to achieve consensus and memos written to explain the analysis [47]. To increase inter-rater coding reliability, only the codes and themes that were validated by at least two of the three coders (the first author, an Iranian and two Australian authors) were included in the results. Immersion in the data was an important first stage in the analysis process during which transcripts were read and re-read many times to ensure familiarity with the data. Repeated reading and re-reading of transcripts without coding helped identify emergent themes from the data without losing the connections between key concepts and their context.

Content analysis was performed using MAXQDA (Ver. 2018) software to facilitate and document the coding process and retrieve codes afterwards. While software can assist researchers to organise qualitative data, computer software for qualitative analysis does not analyse data and the researcher makes decisions about coding participants’ responses, and the relationships between codes, coding categories and broader themes. MAXQDA allows the researcher to upload raw data, such as transcribed interviews, that can be then coded and cross-referenced in ways that facilitate organising the data for easy retrieval.

Search strategy and sources

A literature search of publications in academic journals and conference papers covering the period 2000–2019 was carried out using the following online databases: Google Scholar, Scopus, ProQuest (dissertations and thesis), EBSCOHOST and Science Direct.

Search terms and exclusion/inclusion criteria

The following search terms were employed: “safety work behaviour”, “safety work behaviour model”, “safe behaviour AND petrochemical”, “safety AND behaviour AND workplace”, “safety work behaviour AND model”. The references provided in the publications identified were also examined. When full text publications were not available directly from electronic databases, the authors of studies were contacted and copies of their articles were requested.

The publications were filtered using a set of inclusion and exclusion criteria. Inclusion criteria were that the publication described (1) development of a theoretical model as a tool to assess safe work behaviour, (2) application of a theoretical approach and method which had been used to assess workplace safety, or (3) definitions used to describe and evaluate safe work behaviours. Publications that did not describe the development or application of a safe work behaviour model were excluded, as were those written in languages other than English.

Investigation models

Publications were reviewed to identify theoretical models that have been used to explain and predict safe behaviour in the petrochemical industry or other industrial settings. The key constructs in the models were then evaluated for consistency with the themes identified in our qualitative study of workers in the Iranian petrochemical industry [43] - *poor direct safety management and supervision*; *unsafe workplace conditions*; *workers' perceptions, skills and training*; and *broader organisational factors*. The model including constructs that were most consistent with the qualitative findings was then identified.

Results

Study selection

A flow diagram describing the process for reviewing studies is provided in Fig. 1. In total, 2032 publications were retrieved from the databases described in Sect. 2.1. Duplicate publications were removed and a total of 142 (84 academic journal articles, 58 reports and other publications) were screened by reading the title, abstract and key words. By using the inclusion and exclusion criteria described in Sect. 2.2, 96 articles were excluded from the study, leaving 46 articles eligible for full-text review. During this review, 15 publications were excluded, leaving 31 that were assessed to be eligible. Of the eligible publications, 20 were in academic journals. The remaining 11 included 3 reports, 5 conference papers, and 3 theses (one PhD and two Master’s theses). Appendix A lists the publications reviewed. Table 1 lists the themes, categories and codes that emerged from the content analysis of the semistructured interviews. An overview of the final chosen set of publication eligible for review, and the constructs used in each of them, is provided in Table 2.

Table 1

Classification of themes, categories and codes derived from the content analysis of interview responses from Iranian petrochemical workers

Theme	Category	Code
Poor direct safety management and supervision	Ineffective safety system	- Inadequate safety training for workers and safety staff - Inappropriate quality and design of personal protective equipment - Managers not carrying their safety management role effectively - Sub-standard or inappropriate safety equipment promotes accidents - Supervisors not emphasizing and prioritizing safety - No separate allocation of funds to improve safety
	Poor safety monitoring	- Managers' lack confidence to deal with safety hazards or issues - Safety officers not enforcing safety practices and lacking experience and authority - Inadequate number of safety officers on site - Irregular safety inspections - Contractors not prioritizing safety equipment and training
Unsafe workplace conditions	Unsafe physical environment	- Excessive noise impairing concentration - Use of worn-out and defective equipment - Working in high temperatures

Theme	Category	Code
	Unsafe psychological environment	- Work-related fatigue - Excessive workloads - Delayed salary and wage payments reducing safety incentives - Poor social working environment - Inadequate pay and financial detract from focus on safe behaviour - Low safety motivation - Little encouragement for workers to contribute to safety - Work-related stress - Separation from family - Low level of organizational commitment
Workers' perceptions, skills and training	Workers not skilled enough to deal with safety issues	- Lack of experience and skills in dealing with hazards. - Taking greater risks when doing common tasks - Need for more sharing of previous experiences with hazards - Hazards becoming ‘normalized’ over time - Inadequate safety orientation for new workers - Use of untested work practices
	Active errors	- Workers distracted by making errors - Not seeking help when minor incidents occur - Workers ignoring safety instructions for machinery - Low level of safety efficacy - Unrecognised health conditions contributing to errors

Theme	Category	Code
Broader organisational factors	Unsafe management culture	- Prioritizing work outcomes over safety - Management purchases low-quality safety products and equipment - Condescending safety supervision and bullying
	Organisational impact on workers' safety	- Lack of attention to workers' emotional and mental needs - Lack of organizational safety training at appropriate levels - Workers underestimating routine hazards - Poor organisational safety culture influencing workers' behaviour - Inadequate staffing - Incidents may occur even when workers behave safely

NOTE. Every category is described using codes extracted from the interviews.

Table 2

Description of included studies (listed by year of publication) and the constructs used in each of them

Author	Country of origin	Industry context	Constructs included in the model and matches with needed constructs (a – d, see notes)
1. Griffin and Neal (2000)	Australia	A range of manufacturing and mining organisations	• Manager values • Safety inspections [a] • Personal training [a] • Safety communication [b] • Safety knowledge [a] • Safety compliance • Safety participation
2. Brown et al. (2000)	United States	Steel industry	• Safety hazards • Safety climate • Pressure [b] • Cavaliere attitudes [d] • Safety-efficacy [c] • Safe behaviour
3. Hong et al. (2004)	Taiwan	Petrochemical industry	• Training courses [a] • Workers' cognition & attitude [d] • Behavior and normative belief • Behavior attitude [d] • Subjective norm • Behavior
4. Seo (2005)	United States	Grain industry	• Perceived safety climate • Perceived hazard level • Perceived work pressure [b] • Perceived risk • Perceived barriers • Unsafe work behavior

Author	Country of origin	Industry context	Constructs included in the model and matches with needed constructs (a – d, see notes)
5. Godbey (2006)	United States	Manufacturing facilities	• Safety meetings/training [a] • The behavior of wearing proper PPE [a] • Knowledgeable supervisors and safety managers [a] • Employee involvement and collaboration • Organizational variables • Safety audits • Safety perception [c]
6. Pousette et al. (2008)	Sweden	Construction	• Safety climate [d] • Safety motivation [b] • safety knowledge [a] • Self-rated safety behaviour
7. Larsson et al. (2008)	Sweden	Construction	• Psychological climate (PC) [b] • Job situation (JS) • Workplace commitment (WC) [b] • Safety motivation (SM) [b] • Safety knowledge (SK) [a] • Safety behaviour (SB)

Author	Country of origin	Industry context	Constructs included in the model and matches with needed constructs (a – d, see notes)
8. Zhou et al. (2008)	China	Construction	• Safety climate [d] • Safety management [a] • Management commitments [a] • Safety attitudes [d] • Workmate's influences • Employee's involvement [b] • Personal experience • Safety knowledge [a] • Education experience [a] • Work experience [a] • Drinking habits • Safety behavior
9. Lu and Yang (2010)	Taiwan	Container terminal companies	• Safety motivation [b] • Safety policy • Safety concern • Safety compliance • Safety participation
10. Martínez-Córcoles et al. (2011)	Spain	Nuclear power plant	• Empowerment leadership [a] • Safety culture [d] • Safety climate [d] • Safety behaviours

Author	Country of origin	Industry context	Constructs included in the model and matches with needed constructs (a – d, see notes)
11. Wu et al. (2011)	Taiwan	Petrochemical company	*Safety leadership* [a] • Safety coaching [a] • Safety caring [d] • Safety controlling [a] *Safety climate* [d] • Workers' commitment to safety [b] • Perceived risk [c] • Emergency response [b] *Safety performance* • Safety inspection [a] • Accident investigation [c] • Safety training [a] • Safety motivation [b]
12. Isha, (2012)	Malaysia	Petrochemical industry	• Safety management and environment [a] • Safety priority [d] • Management commitment to safety [a] • Involvement [b] • Supportive environment and communication [b] • Personal views on safety factors • Safety Culture [d] • Psychosocial hazards at work [b] • Physical hazards at work [b]

Author	Country of origin	Industry context	Constructs included in the model and matches with needed constructs (a – d, see notes)
13. Li et al. (2013)	China	Oil company	• Job demands [b] • Job resources • Emotional exhaustion • Safety compliance • Safety outcomes
14. Qinqin et al. (2014)	China	Petrochemical industry	• Hazardous materials • Production process • Equipment condition [a] • Environmental safety and health • Vulnerability of receptor [c]
15. Shin et al. (2015)	South Korea	Construction	• Management values • Safety climate [d] • Stress response [b] • Safety motivation [b] • Safety knowledge [a] • Safety behavior
16. Wu et al. (2015)	China	Railway construction	• Safety leadership [a] • Design and planning for safety • Preconstruction hazard inspection [a] • Construction process safety • Emergency preparedness [b] • Management auditing and organizational learning • Safety performance

Author	Country of origin	Industry context	Constructs included in the model and matches with needed constructs (a – d, see notes)
17. Azadeh et al. (2015)	Iran	Petrochemical plant	• Physical factors of workplace [b] • Environmental features and issues [b] • Management systems and control [a] • Individual protection tools [a] • Workplace safety actions • On-the-job training [a] • Passing ways • Monitors and displays [a] • Muscular and skeletal disorders [c] • Anthropometric features and issues • Job characteristics • Layout feature and issues • Job and environmental satisfactions • Overall HSE management and performance [a] • Mental workload and stress [b]
18. Alshahrani et al. (2015)	Saudi Arabia	Petrochemical industry	• Safety culture [d] • Safety attitudes [d] • Safety and health requirements to circumvent accidents at workplace • Safety behaviour • Safety performance

Author	Country of origin	Industry context	Constructs included in the model and matches with needed constructs (a – d, see notes)
19. Wang et al. (2016)	China	Construction	• Personal subjective perception • Work knowledge and experiences [c] • Work characteristics • Safety management [a] • Workers' safety risk tolerance
20. Zhang et al. (2016)	China	Coal Mining	• Safety management agency [a] • Rules and regulations of safety production [a] • Defect of technology and design [b] • Lack of safety education and training [a] • Incomplete or poor execution of rules and regulations • Rules and regulations and inspection [a] • Safety culture [d] • Operator error • Venturing into dangerous places • Protections, and devices signals deficiencies [a] • Equipment, facilities and tools [a] • Poor workplace environment [b]
21. Petitta et al. (2017)	Italy	Manufacturing, construction, transportation, military, energy, health care and distribution/service	• Safety compliance • Supervisor enforcement [a] • Organisational safety climate [d] • Organisational safety culture [d]

Author	Country of origin	Industry context	Constructs included in the model and matches with needed constructs (a – d, see notes)
22. Zaira and Hadikusumo (2017)	Malaysia	Construction	• Management safety intervention [a] • Human safety intervention • Technical safety intervention • Safety behaviour
23. Jafari et al. (2017)	Iran	Petrochemical company	• Management commitment [a] • Workers' empowerment • Communication [b] • Blame culture • Safety training [a] • Safety supervision [a] • Interpersonal relationship [b] • Continuous improvement • Reward system [b] • Job satisfaction
24. Razmara et al. (2018)	Iran	Taxi stations	• Perceived susceptibility • Perceived severity • Perceived benefits [c] • Perceived barriers [c] • Self-efficacy [c] • Cues to action • Safe driving behaviours

Author	Country of origin	Industry context	Constructs included in the model and matches with needed constructs (a – d, see notes)
25. Nioi et al. (2018)	United Kingdom	Construction	• Behavioural beliefs [c] • Normative beliefs • Control beliefs • Attitudes toward the behaviour [d] • Subjective norms • Perceived control [c] • Behavioural intention [c] • Behaviour
26. Hald (2018)	China	Electronics industry	• Safety climate • Safety hazards • Experience with safety and health problems [c] • Pressure [b] • Employees' knowledge of the factory [a] • Cavalier attitudes towards safety • Safety efficacy [c] • Safe workplace behaviour
27. Zhang et al. (2018)	China	Petrochemical enterprise	• Personnel training [a] • Fire facilities • Fire management • Technical level

Author	Country of origin	Industry context	Constructs included in the model and matches with needed constructs (a – d, see notes)
28. Nedzamba (2018)	South Africa	Petrochemical industry	• Safety Management [a] • Risk Behaviour • Safety Systems and Training [a] • Receptiveness towards Safety Information • Prioritising Safety [d] • Reporting incidents and near-misses [c] • Equipment, Tools and Working Conditions [a] • Safety Promotion • Reactions to Safety Investigations • Compliance
29. Newaz et al. (2019)	Australia	Construction	• Management safety commitment (MSC) [a] • Supervisor safety behaviour (SSB) [a] • Co-worker safety behaviour (CSB) • Psychological contract of safety (PCS) [b] • Worker Safety Behaviour (WSB)

Author	Country of origin	Industry context	Constructs included in the model and matches with needed constructs (a – d, see notes)
30. Gao et al. (2019)	China	Oil industry	• leadership/management commitment (LMC) [a] • organizing responsibilities/procedures (ORP) • communication and coordination (CC) [b] • safety training (ST) [a] • inspection and monitoring (IM) [a] • employee involvement (EI) [b]
31. Wang et al. (2019)	China	Coal Mining	• Workers' characteristics • Workers' Perception of safety • Working pressure [b] • Leader's attitude in meeting • Inspectors' quality [a] • Management system's integrity [a] Management system's stringency [a]

Notes: [a] *poor direct safety management and supervision*

[b] *unsafe workplace conditions*

[c] *workers' perceptions, skills and training*

[d] *broader organisational factors.*

Study characteristics

Twelve (38.7%) studies were conducted in a single industry (steel[2], grain[4], manufacturing[5], container terminal companies[9], nuclear power[10], oil[13,30], railway construction[16], coal mining[20,31], taxi stations[24], electronics[26]), and two (6.45%) included multiple industries (1, 8). Industries attracting the most studies were the petrochemical (n = 9) and construction (n = 8) industries. Ten were conducted in China.

Contributing factors

Elements of the models presented in the 31 selected studies were evaluated for consistency with the four factors identified in our previous study - *poor direct safety management and supervision*, *unsafe workplace conditions*, *workers' perceptions, skills and training*, and *broader organisational factors*. All the emergent themes, categories and codes matched up directly with each of the constructs were included in the models in the general industrial settings and petrochemical industry.

Concept matches in each of the studies have been highlighted in Table 2 by labelling each match (a, b, c, or d) to indicate which of our four contributing factors it corresponds with. Based on the number of these matches, the model most consistent with the four contributing factors was identified.

The *poor direct safety management and supervision* theme combines two categories including ineffective safety system and poor safety monitoring. Concepts in the reviewed models that correspond with these categories have been labelled 'a'. Table 2. Of the 31 studies evaluated, the model constructs of 24 (77%) studies were matched with categories and codes of theme ‘a’ (1, 3, 5, 6, 7, 8, 10, 11, 12, 14, 15, 16, 17, 19, 20, 21, 22, 23, 26, 27, 28, 29, 30, 31).

The *unsafe workplace conditions* theme includes two categories: unsafe physical environment and unsafe psychological environment. The codes of these categories have been matched with concepts in the reviewed models by using the character 'b' in Table 2. Of the 31 assessed studies, constructs included in the model of 19 (61%) studies were matched with categories and codes of theme ‘b’ (1, 2, 4, 6, 7, 8, 9, 11, 12, 13, 15, 16, 17, 20, 23, 26, 29, 30, 31).

The *workers' perceptions, skills and training* theme comprises two categories: workers not skilled enough to deal with safety issues and active errors. The codes of these categories have been matched with concepts in the reviewed models by using the character 'c' in Table 2. 10 (32%) of the 31 studies found constructs included in the model and matches with categories and codes of theme ‘c’ (2, 5, 11, 14, 17, 19, 24, 25, 26, 28).

The *broader organisational factors* theme includes unsafe management culture and organisational impact on workers' safety categories. The codes of these categories have been matched with concepts in the reviewed models by using the character 'd' in Table 2. Constructs applied in 13 (42%) of the 31 studies included in the literature review were matched with categories and codes of theme ‘d’ (2, 3, 6, 8, 10, 11, 12, 15, 18, 29, 21, 25, 28).

Selection of the theoretical model

The purpose of reviewing the models of safe work behaviours was to 1) identify constructs included in the selected models; and 2) identify the model that included constructs most consistent with the findings of the preceding qualitative study of Iranian petrochemical workers’ perceptions of factors affecting safe work behaviours [43]. The constructs identified in the model described by Wu et al. (2011, see Table 2), most closely matched those identified in the qualitative study. [42] proposed a theoretical model relating to safety behaviours in a petrochemical company and explored three major factors including *safety leadership, safety climate*, and *safety performance*. Safety leadership consisted of three sub-scales: *safety coaching, safety caring, and safety controlling*. Safety climate also included three sub-scales: *workers’ commitment to safety, perceived risk, and emergency response*. Safety performance included four sub-scales: *safety inspection, accident investigation, safety training, and safety motivation*. The constructs described by Wu et al. (2011) were well matched to the contributing factors identified in our qualitative study: safety leadership and its sub-scales matched with poor direct safety management and supervision; safety climate and its sub-scales matched with unsafe workplace conditions; safety performance and its sub-scales matched with workers' perceptions, skills and training; and codes from several sub-scales matched with broader organisational factors.

Discussion

This study evaluated the consistency between thirty-one theoretical models proposed to explain and predict safe behaviours in industrial settings and qualitative findings from a study examining the factors that petrochemical workers perceived to affect safe behaviours. The first aim of a literature review was to identify theoretical models developed to explain and predict safe behaviour in both the petrochemical industry and general industrial settings. The second aim of the current study was to select the model that corresponds substantially with our qualitative findings. The majority of the included studies were found to be focused on some aspects of our qualitative data. Additionally, most these studies were conducted in various industrial domains.

The present findings indicate that the key elements of the model described by Wu et al. [42] correspondence most strongly with the themes derived from our qualitative interview study. Several of the other models identified in the review also included elements that corresponded closely with the themes identified in our interview study. Based on the findings from our review, the safety concern from managers and supervisors is identified the most key factor affecting the workers' risk perception and their understanding of safety issues [19, 42, 49-51]. In addition, supervisors' safe behaviours such as regular safety inspection, motivating and supporting the subordinates, and providing resources for appropriate training of the workforce can motivate safety performance, encourage workers' participation as well as reporting potential incidents and unsafe behaviours [41, 52-56]. These findings are consistent with the *poor direct safety management and supervision* theme of our qualitative study. The included studies assessed the relationship between safety climate and workers' perceptions of safety issues, and various aspects of safety-related behaviour. These studies examined work safety climate and aspects of working conditions and their association with occupational safety and work-related injuries among various workplace settings [11, 42, 56-58]. They focus mainly on improving working conditions and its organizational and psychological aspects such as perceived work pressure, emergency response, physical and psychosocial hazards at work, job demands, physical factors of workplace, mental workload and stress, and defect of technology and design [42, 50, 51, 58-60]. These results support our qualitative findings related to *the unsafe workplace conditions* theme. According to a review of 31 studies, adequate and appropriate job training, workers' perception of risk, and their knowledge of health and safety issues were negatively correlated with occupational accident rates [52, 55, 61]. Workers' skills and perceptions of their own behaviour plays a significant role to produce better safety outcomes [27, 30, 42, 54, 62]. These findings are also consistent with the workers' perceptions, skills and training theme of the qualitative study. The findings of included studies also focused on the importance of management culture and organisational impact on workers' safety. These findings highlight that workers' cognition and attitude, safety culture and prioritising safety can influence workers to adopt positive behavioural intentions towards safety at workplace [6, 14, 42, 49, 50, 61, 63, 64]. These findings also support the fourth them of our qualitative findings: *broader organisational factors*.

The core themes that emerged from our previous study suggest that a well-suited conceptual model can be employed to train workers and promote their safe work behaviours in the workplace [65]. Wu et al.'s (2011) model suggests that two important prior causes greatly affect safe behaviours and performance: safety leadership and safety climate. In this context, the role of managers and supervisors in shaping subordinates' safe behaviours is likely to be considerably greater than in work settings with routine production processes [66]. Consistent with our prior research, the results indicated that supervisor enforcement is significantly related to workers' safety compliance [67]. Supervisors have the most frequent contact with employees and workers among the hierarchical levels of an organisation and are directly responsible to guarantee safety performance at the workplace. Managers' responses to safety are a key determinant in the creation of subordinates' beliefs about the importance of safety to the work settings [68, 69]. As expected, a positive safety culture will be developed when managers commit to the priority of safety [41]. In addition, workers perceive that the role of both the managers and supervisors in combination with their safety commitments enables workers to develop a mutual obligation with them and these obligations will lead to safer behaviour of workers [70].

Our previous qualitative findings indicated that unsafe workplace conditions may be a particularly strong influence on whether work is done safely or not. Wu et al. (2011) defined safety climate as "employees' imaging of safety conditions in the workplace", which images then affect organizational safety activities and safety results". The relationship between safety climate and safe work behaviour has been well established in safety research and safety climate has been identified as a critical indicator for enhanced safety, which has been linked to increased safe behaviours and decreased injury severity in industrial settings [71-73]. Safety climate is therefore related to how workers perceive organisational priorities in their workplace and has a major role in motivating workers to work safely [74]. Safety climate is indicated by the perceptions of norms and actions that help to prevent unsafe acts [20]. Furthermore, Beus et al. [75] reported that a supportive safety climate is associated with higher rule compliance and fewer work-related injuries. A positive organization's safety climate provides workers with cues and vital information regarding the extent to which safe behaviours are valued, supported, and rewarded in the workplace [76]. Studies have shown that safety climate scores are significantly predictive of worker safety attitudes, safety compliance and performance, workplace accidents, injuries, near misses, safety knowledge and safety motivation [77-79].

Another factor identified in our previous paper was workers' perceptions, skills and training. Occupational hazards and safety performances are affected by factors included workers' safety attitude and knowledge [42]. Findings indicate that workers with more knowledge of the products, work environment and objectives of the organisation demonstrated a higher level of safe behaviours in their contexts, as compared to their ignorant colleagues [80]. Workers' knowledge, skills and competence with regard to safety are the required content of safety training [81, 82]. Workers who do not fully understand the safety and health instructions that are related to their jobs tend to experience higher accident rates. In addition, due to differences of education level, safety training should be provided separately according to workers' education levels and ages. Therefore, safety training should be designed in accordance with the requirements for workers to be aware of safety at work [62, 83]. Korkmaz and Park [62] also agreed that workers who are familiar with their job tasks could help to involve in risk assessment in the workplace. Researchers [84, 85] found that organizations can have low injury and accident rates when they when they predict and implement practical safety training regularly.

In Wu et al.'s (2011) model safety performance reflects the workers' perceptions, skills and training. Safety leadership has been associated with safety management and supervision, in general. Further, dimensions of safety climate (workers' commitment to safety, perceived risk, and emergency response) are consistent with categories and codes of the unsafe workplace conditions theme.

According to the above mentioned, as our qualitative findings align with the dimensions of established model by [42], we evaluate this model as applicable in order to design educational intervention for petrochemical workers. Technical intervention safety practices have a positive effect on safe work behaviours. In addition, the management safety intervention plays a significant role in the implementation of safety practices. Therefore, this model provides some guidance to industrial companies to better focus on specific safety intervention practices that improve workers' safe behaviours and their safety awareness to work safely.

Implications for research and practice

The current literature search identified 31 studies that served as exemplars of the translation of safety model into intervention efforts which can guide workplaces in improving their safety conditions and reducing accident rates. When reviewing the models in the 31 selected studies, the main feature of the model was assumed from the assessment of general levels of safety and major components of conceptualizing safety (e.g., safety management, safety climate) to special and detailed latent hazard conditions, such as levels of organisational support and risk perceptions might be seen to imply that safety models are seen as ways to assess the wider and bigger picture of how safety promotion might work in industrial contexts.

Limitations of this research

This study enhances understanding of the factors affecting safe work behaviour and highlights directions for further research. Some important limitations should be recognised however. A key limitation, which was difficult to avoid, is the exclusive focus on published research. This review included studies published in peer-reviewed journals. Although this was done to provide a high quality of evidence and findings, the criteria excluded a number of potentially valuable research and industry reports or unpublished studies. Evidence suggests that use of workplace safety models may be underreported. The studies identified, which were drawn from a variety of settings (e.g., petrochemical, construction, oil and gas), indicated that safety models are widely used by organisations which are eager to develop better understanding of safety risks in their workplaces. A key weakness of the safety model approach may be that results obtained at one point in time may not prove to be repeatable at another. The studies reviewed in this paper do not allow firm conclusions to be drawn about the reliability, validity and overall robustness of using safety models in practice. Deeper investigation into these issues would be a valuable focus for future research. The aim of the improvement plan is to have a better safety status by making suggestions for the Iranian petrochemical industry for workers. However, this may be applied in other countries. Nevertheless, this subject should be studied more for other industrial settings and countries in order to reach a more generalized result.

Conclusions

This study is the first, to our knowledge, to examine the extent to which the key variables in theoretical frameworks designed to explain safety behaviours at to identify potentially relevant theoretical models on safe behaviour, as well as to evaluate the suitability and applicability of the models identified to explaining the safety of petrochemical workers based on our previous findings regarding the factors that discourage safe work behaviours. The findings indicate that on the one hand growth in terms of the use of safety models in order to assess workers’ safe behaviours, but also significant variation in the ways in which they are used and reported in the safety literature. For safety researchers and practitioners results would be important because the structural model predict how workers may be influenced to work more safely. Based on the importance of safety intervention for changing unsafe to safe work behaviours, an integrated safety intervention model can encourage positive workers' safety performance. Lastly, this study has implications for leadership at both the supervisory and management levels by identifying the effects of supervisor' behaviours and safety climate as determinants of safety performance. Taken as a whole, our findings encourage a holistic approach that takes into account both safety management and climate in order to comprehensively understand the individual and contextual factors that shape safe work behaviours in the petrochemical industry. It is important that future theoretical and conceptual framework efforts address the inconsistencies identified in the current study to enable the adoption and replication of safe behaviour interventions in industry, preventing workplace injuries and fatalities in order to make workplace a healthy and safe place to be.

Abbreviations

ILO: International Labour Organization

PPE: Personal Protective Equipment

HBM: Health Belief Model

TPB: Theory of Planned Behaviour

RPA: Risk Perception Attitude

SCT: Social Cognitive Theory

Declarations

Ethics approval and consent to participate

Ethical approval was granted by Tarbiat Modares University, Faculty of Medical Sciences, Ethics Committee (Approval ID: IR.TMU.REC.1395.503) and the trial is registered in Iranian Registry of Clinical Trials (reference: IRCT20170515033981N2). All participants provided written consent for the study, were made aware that data were anonymised, securely stored, analysed for publication, participation was voluntary and they were free to leave the study at any time.

Consent for publication

Not applicable.

Availability of data and materials

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions

AZH was the main investigator, collected and analysed the qualitative data, conducted a literature review to identify theoretical models and wrote the first draft of manuscript. FG is the dissertation supervisor and contributed to the conception and design of the study. HS, FAS and PB were study advisors. AZH spent her sabbatical leave as a Visiting Researcher in the Faculty of Medicine and Health Sciences, The University of Sydney under the supervision of PB and LM. FG, HS, FAS, PB and LM were involved in revising the manuscript for intellectual content and AZH, PB and LM finalized the manuscript. AZH, FG, HS and FAS contributed to analysing qualitative data. Qualitative findings were repeatedly discussed and revised, and the theoretical models were investigated by AZH, PB and LM. PB and LM made significant contributions to critical editing of English grammar. All authors have read and approved the final manuscript.

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Authors' Information

[1] Department of Health Education, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, Iran

[2] Faculty of Medicine and Health, The University of Sydney, Sydney, Australia.

[3] Tasmanian School of Business and Economics, University of Tasmania, Private Bag 84, Hobart, Tasmania 7001, Australia

[4] Work and Health Research Team, Faculty of Medicine and Health, The University of Sydney, Sydney, Australia

[5] Health Research Center, Lifestyle institute, Baqiyatallah University of Medical Sciences, Tehran, Iran

[6] School of Business, School of Accounting, Western Sydney University, Sydney, Australia

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Figures

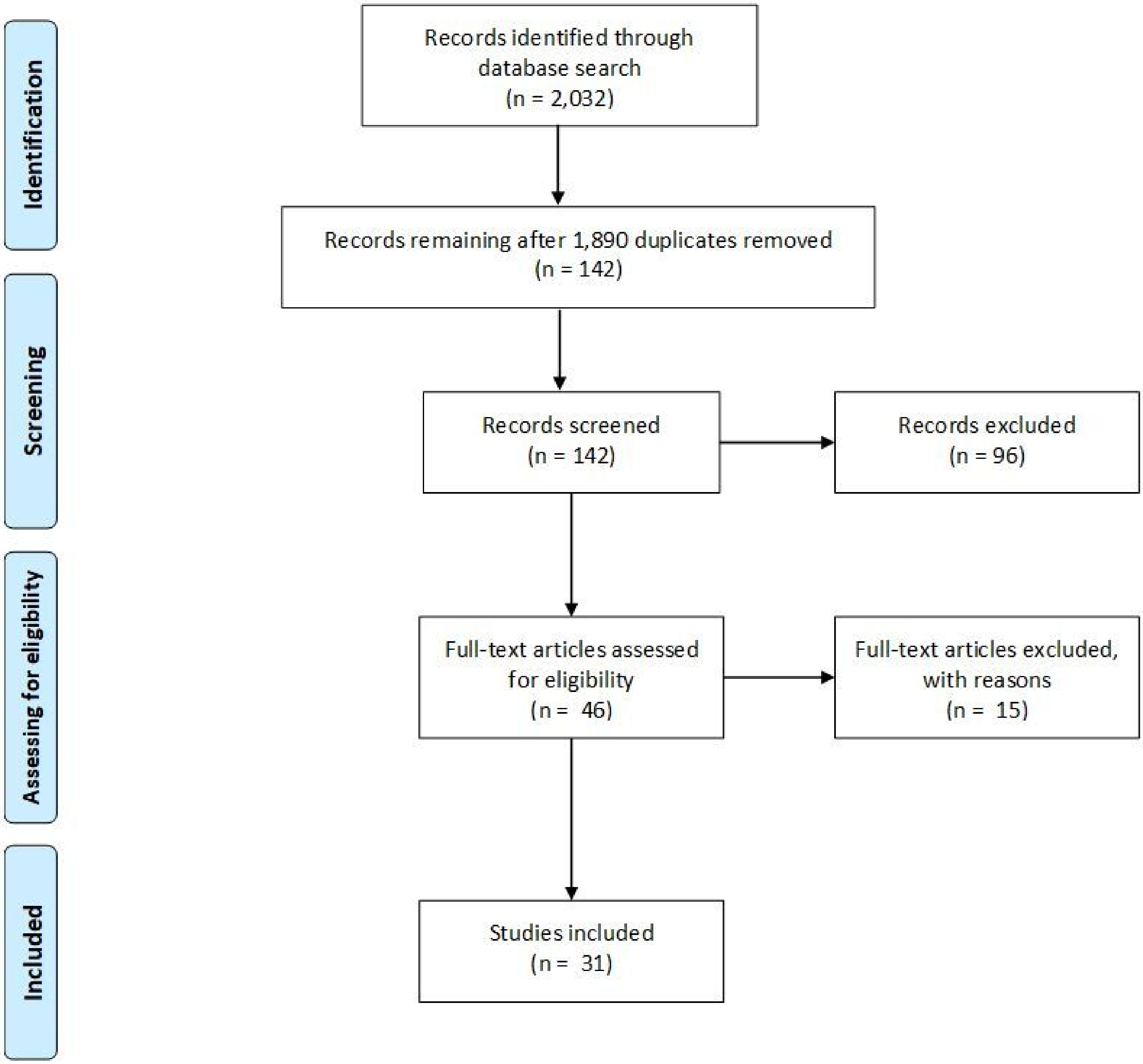

Figure 1

Flow diagram of search results and study selection process using the PRISMA template [48].

Supplementary Files

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