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What Are the Factors Influence on Construction Safety? A Review

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Abstract: Because of resource constraints, construction safety management is more difficult in underdeveloped nations. The aim of this paper is to explore and identify the key factors affecting construction site safety performance. The first step in this study was a systematic assessment of 98 papers using a content qualitative approach. From this review, 12 influential factors for safety performance in construction projects were identified. Second, a framework was developed to illustrate the interactions between the identified factors at various project management levels. Furthermore, expert interviews were used to validate the framework. The findings of this study will help project managers better understand how different important safety issues at different construction project hierarchies affect the safety performance of the sites.
Keywords: Safety performance; Safety factors; Construction safety; Content analysis; Literature review.

1. Introduction

The construction sector is considered the most accident-prone sector due to its nature and uniqueness [1 - 3]. Besides this, the impact of accidents in construction sites causes direct and indirect losses to the affected workers, their families, employers, and even society [4 - 6]. In many cases, indirect losses are much more than direct losses which impact the sustainable growth of the overall construction sector. In developing countries, almost 30% of the workforce is employed in this sector, which is responsible for almost 40% of workplace accidents [7, 8]. However, the construction sector is crucial to the economic growth of the countries as well as a solid solution to the problem of unemployment in many developing countries. For this reason, such devastating statistics cannot be held as a piece of evidence against the irreplaceable of this industry [9 - 12]. For example, in Bangladesh, the construction sector contributes nearly 8% of the country's GDP [13 - 15]. Therefore, the success of the construction companies impacts the development of the economies of the countries [16]. Considering the value of engineering, the productivity and profitability of construction companies depend on time, cost, quality, and safety [17 - 20]. On one hand, the successful completion of construction projects is not always described by the time, cost, and quality but also client's expectation of the safety performance of the sites [21, 22]. On another hand, though the cost of casualties in sites often significantly impacts the profitability of the construction companies, the safety measures are not only for health concerns but also for both financial and managerial aspects, safety measures are a critical concept in the construction industry [23 - 27, 2].

2. Literature Review

It is important to note that despite having plenty of construction safety literature, the accident rate in construction sites is still alarming [28, 29, 30]. However, the prevention of the accident depends on how well the factors of causation are mitigated [31, 32, 33]. Therefore, this study is focused on the critical factors that impact safety performance in the sites. The top management of the construction companies should also take care of the critical factors to ensure the safety performance of the sites, which ultimately reflects their profitability and productivity [34, 35, 36, 24]. Moreover, a framework has been developed in this study to investigate the impact of the factors on the safety performance of the sites. The developing countries' construction safety is more complex than other developed countries due to unskilled labor management [37, 24, 12]. However, there are similarities in the critical factors for safety performance among developing countries. For example, Yap and Lee [38] studied construction safety performance in Malaysia and found that personal protective equipment, working environment, working attitude, communication, and maintenance of equipment were the influential factors in the Malaysian construction sector. According to Aksorn and Hadikusumo [7], management support, safety education and training, construction teamwork, construction project goals, and safety enforcement schemes were considered the critical success factors for the construction safety performance of the Thai construction sector. Alhadir and

Panuwatwanich [39] considered management support, construction project objectives, working attitudes, construction teamwork, and safety enforcement were the most important factors for ensuring safety performance in Saudi construction industries. Moreover, for China safety awareness of employers, safety training, resource allocation of safety and reckless operations can be considered the critical success factor for construction safety [40]. For the Egyptian construction sector safety inspections, safety records, project finance investment, management commitment, and safety meetings were the critical success factors for the safety condition of the construction projects [41]. Durdyev et al. [42] studied the Cambodian construction industry and found safety training, reckless operation, worker's skill competencies, poor equipment, and workers' education level were the critical success factors for the safety performance of construction projects. Adding more, in Bangladesh safety regulations, management support, safety training, safety culture, and budget for safety were considered the influential factors for safety performance [15] . Table 1 represents the factors influencing construction safety.

Table 1. Factors influencing construction safety.

	Main Factor	Sub-factor
1	Safety legislation	Safety rules monitoring [28]; [9]; [6]; [43]; [39]; [31]; [21]
		Safety rules [7]; [16]; [43]; [44]; [45]; [22]; [46]; [47]
		Safety rules documentation [43]; [44]; [5]; [48]; [49]; [29]
2	Competency in Health and Safety	Experience in safety [50]; [8]; [51]
		Safety training [52]; [8]; [9]; [6]; [43]; [17, 45]; [44] [53]; [30]; [35]; [7]; [18]; [46]; [54]
		Safety knowledge: [6]; [37]; [43]; [55]; [56]; [30]; [57]; [58]
		Contractor's competency [37]; [21]; [22]; [31]; [33]; [59]; [25]; [26]
3	Motivation	Job Satisfaction [60]; [3]; [61]; [58]; [54]
		Compensations [9]; [43]; [62]; [58]; [35]
		Rewards & Incentive schemes [11]; [62]; [61]; [16]; [35]; [26]; [31]
		Peer support [3]; [50]; [22]; [34]; [49]; [22]; [36]
4	Productivity and financial aspects	Project schedule [4]; [44]; [19]; [20]; [11]
		Quality [63]; [18]; [16]; [9]
		Productivity [44]; [16]; [64]; [19]; [20]; [11]; [48]
		Reworking [44]; [37]; [19]; [20]
		Project size [43]; [16]; [28]; [59]; [22]
		Project cost [2] [20]; [19]; [4]; [44]
		Error in design [22]; [59]; [21]; [37]; [65]; [17]; [66]
5	Resources for safety	Safety Equipment [67]; [68]; [40]; [61]; [69]; [70]
		Safety Personnel [36]; [51]; [71]; [8]; [69]; [24]; [47]; [29]; [46]; [23]; [22]; [36]
		Safety resource allocation [72]; [62]; [43]; [6]; [16]; [9]; [28]; [73]
6	Working Environment	Work condition [69]; [60]; [3]; [6]; [65]; [17]; [74]; [75]; [54]; [12]; [18]
		Worker's welfare [4]; [72]; [61]; [58]; [35]; [24]; [46];
		Site housekeeping [31]; [29]; [9]; [65]; [43]; [62]; [74]; [54]; [70]
		Material storage [76]; [50]; [49]
		Hazardous materials handling [51]; [74]; [75]; [11]; [49]; [65]; [76]; [50]
7	Work stress	Working shift scheduling [6]; [28]; [61]; [3]; [16]; [31]
		Overloaded work pressure [73]; [9]; [3]; [10]
		Breaktime [3]; [6]; [60]; [10]
		Fatigue [69]; [60]; [3]; [10]; [23]
8	Safety Management System	Safety policy [16]; [6]; [37]; [43]; [53]; [39]; [45]; [48]; [54]; [47]; [29]; [77]; [22]; [78]
		Top management commitment [9]; [16]; [50]; [79]; [32]; [21]; [40]; [66]; [22]; [33]; [77]; [12]; [47]; [54]; [24]; [26]
		Safety monitoring mechanism [29]; [31]; [72]; [76]; [5]; [44]; [6]; [9]; [58]; [35]; [54]
		Safety Committee [71]; [28]; [9]; [16]; [6]; [50]; [73]; [49]; [29]; [47]; [35]
		Project management [28]; [60]; [9]; [10]; [43]; [62]; [44]; [7]; [51]; [2]; [80]; [34]; [58]; [70]; [68]
		Safety plans [43]; [16]; [9]; [28]; [12]; [54]; [35];
		Safety records [69]; [81]; [16]; [6]; [71]; [26]; [54]; [29]; [82]
		Safety response data on site [83]; [65]; [62]; [27]; [75]; [54]
`		Safety framework [16]; [6]; [76]; [56]
9	Organization	Size of organization [69]; [9]; [37]; [43]; [58]; [84]

		Organization structure [43]; [50]; [4]; [7]; [12]
		Communication [5]; [9]; [6]; [43]; [35]; [84]; [46]
		Recruiting system [50]; [53]; [43]; [37]
		Employee benefits [72]; [61]; [85]; [62]; [50]; [53]
		Employee retention rate [69]; [3]; [37]; [50]; [77]; [79]
		Leadership [50]; [3]; [44]; [69]; [80]; [29];
10	Accident records	Record documentation [81]; [16]; [5]; [44]
		Record keeping manual [5]; [85]; [44]
		Record keeping procedures [10]; [37]
		Accident Rate [70]; [86]; [87]; [16]; [37]; [65]; [75]; [88]
		Accident types [89]; [90]; [62]; [44]; [72]; [37]; [74]; [27]
		Investigation Procedure [54]; [91]; [37]; [16]; [28]; [6]; [43]; [17]; [87]; [32]
		Investigation documentation [5]; [72]; [44]; [6]; [70]
11	Safety Attitude	Workers Behavior [8]; [69]; [3]; [65]; [85]; [53]; [55]; [12]; [22]; [87]; [57]
		Workers Attitude [72]; [62]; [8]; [46]; [31]; [70]; [57]; [21]
		Worker's response [73]; [49]; [46]; [69]; [28]; [37]; [65]; [21]; [57]; [33]; [18]; [34]
		Supervisor's skill [36]; [8]; [62]; [85]; [53]; [30]; [58]; [26]; [54]; [46]; [23]; [31]; [77]
		Supervisor's responsibilities [33]; [46]; [69]; [9]; [43]; [50]; [61]; [79]; [36]
		Risk-taking perception [62]; [6]; [60]; [48]; [27]; [29]; [22]
		Mental condition [24]; [28]; [3]; [6]; [50]; [85]; [68]; [31]; [46]
12	Safety Budget	Safety Budget Requirement [75]; [47]; [20]; [4]; [62]; [28] ; [22]; [31]
		Safety budget approval [10]; [16]; [47]; [54]; [48]; [2]; [59]
		Safety budget allocation [74]; [2]; [47]; [6]; [16]; [63]; [59]; [29]
		Safety budget assessment [46]; [44]; [62]; [47]; [2]

Overall, it can be said that although there have been several earlier works on construction safety, most of them have focused on particular areas in specific countries rather than a thorough and organized one [45, 2, 48, 35]. Moreover, previous studies extracted the critical success factors by using mostly questionaries and interviews [7, 45, 24, 47, 12, 46, 88]. Due to these limitations, applying newly developed outcomes to projects in various other developing nations is challenging. Therefore, this research aims to address this gap by creating a thorough framework to identify the variables influencing the safety performance of building projects, particularly those in developing countries. The objectives of the study are to (a) investigate the variables that affect safety performance on construction projects in developing countries and (b) develop a framework to show how the identified variables interact in the construction sector.

3. Method

In the first step, the papers that were published from 2016 to 2022 were searched from the database, and in the second step, the publication date was expanded from 2000 to 2016. Therefore, papers from almost 22 years are searched using the keywords "Construction Safety", "Safety Performance" and "Factors in Construction Safety". The titles and abstracts were reviewed first and then the relevant papers were selected for further review. A total of 98 papers were reviewed in this study to identify the influential factors. Using the content analysis approach, all the papers were grouped based on their types, objectives, methods, results, year, and origin. Table 2 represents the sample table of extracted data from reviewed papers.

In content analysis, a systematic and replicable technique is used for compressing many words of text into fewer content categories based on explicit rules of coding to extract variables. Variables that had similar meanings or implications were merged and deleted to summarize some key factors. Figure 1 illustrates the flowchart of the study.

After that, a thorough framework was created in this study to demonstrate how the major factors were impacted at each level of the construction project hierarchy, from the government to the individual. Therefore, a total of 5 semi-structured interviews were conducted with 2 project managers, 2 safety researchers, and 1 government officer to validate the framework. The participants were selected from the list of professionals of Institute of Engineers Bangladesh. All the participants have more than 10 years of experience in the field of construction management where the mean experience was 12 years. Based on their personal experience and literature review, the respondents extracted the most influential key factors for different hierarchical levels of safety management.

Table 2. A sample table of extracted data from reviewed papers

Title	Journal	Year	Paper Type	Method of Data Collection	Analytical Method	Research objective	Key Findings	Country
Analysing the underlying factors affecting safety performance in building construction	Production Planning & Control	2020	Quantitative	Structured interviews, archival records and questionnaires	Correlational research (regression)	to determine the significant factors affecting safety performance and to evaluate the potential measures for improving the construction workers' safety awareness	safety issues are personal protective equipment, working environment, working attitude, communication, and maintenance of equipment.	Malaysia
Critical success factors influencing safety program performance in Thai construction projects.	Safety Science	2008	Mixed	Structured interviews, archival records and questionnaires	Statistical analysis (ttest, correlation)	To identify critical success factors influencing safety program performance	Identified 16 critical success factors (CSFs) of safety program.	Thailand

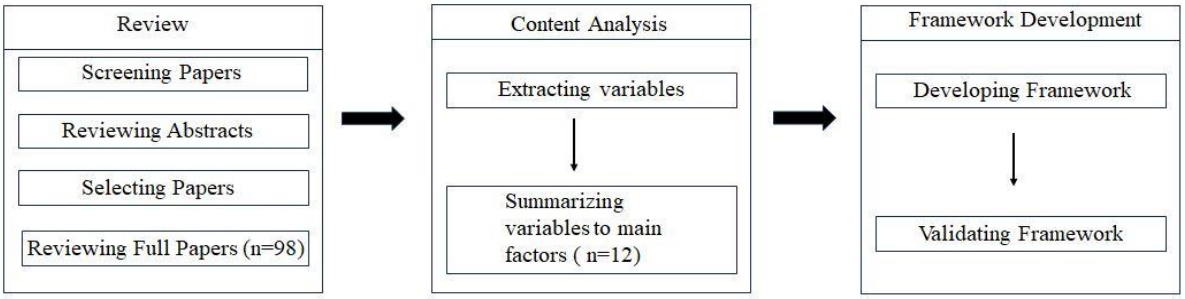

Figure 1. Flowchart of the study

4. Results and discussion

It was found in this review article that each main factor had several supporting factors and that these supporting factors were mentioned in several papers. The extracted main factors from the literature review are described in this section:

4.1 Safety legislation

The factor safety legislation includes safety rules, regulations, and compliances which play a critical role in safety management within the organization [28, 9, 6, 43, 39, 31, 21]. Many researchers [7, 16, 43] found that the implementation of construction safety rules is different in different types of organizations. Simultaneously, the same organizations react differently in implementing the safety rules based on the owners and scale of the projects [69, 9, 37, 43, 58, 84]. For example, medium and small-scale organizations are more reluctant in implementing construction safety laws and regulations [50, 4, 7, 12]. Safety regulations determine the basic requirement of investment in safety programs [22, 46, 47]. However, safety legislation requires a lot of paperwork for the successful implementation of construction safety in projects [6, 43, 44, 5, 48, 49, 29]. Government or industrial regulations also help to design safety programs effectively considering all levels of hierarchy [2]. Workers' behavior, attitude, organizational structure, and client acceptance also impact the successful implementation of safety legislation [69, 35]. Therefore, this factor influences the relationship between the government agencies and the main contractor, the main contractor with the sub-contractor, and the main contractor with the owner [22, 21].

4.2 Competency in health and safety

Health and safety competency depends on the safety training, knowledge, skill, attitude, and prequalification of the contractors and sub-contractors [43, 86, 56, 30, 57]. Many researchers found that safety training increases the safety awareness of workers [53, 35]. Hence, in developing countries, maximum construction workers are seasonal, and their safety behavior is a challenge to enhance the safety performance of the construction sites [12, 22, 87, 57]. Through training, organizations not only help to increase their safety competency but also help to increase the productivity of the operations [52, 8, 28]. In toolbox meetings, workers are not only trained on safety issues but also on the overall operation of the sites [31]. Moreover, this safety training is also backed by legal or legislative which is the basic requirement for safety measures by authorities [18, 46, 54]. Thus, safety training increases safety knowledge, which reflects an individual's understanding and mastery of how well the safety regulations could be applied in the projects [55, 56]. Furthermore, this safety knowledge impacts the workers' safety behavior, which helps them enhance their ability to work safely under adverse working conditions [82, 79]. Moreover, competency in health and safety is a critical section factor for contractors or subcontractors by the owner as per tender documents [57, 33]. Adding more, the health and safety competency also depends on the age of the worker [60]. Many studies found that older workers got more serious types of injuries than younger workers though the young workers were more accident-prone [88]. The factor related to competency in health and safety influences the relationship between the owner or organization to main contractors and main contractors to sub-contractors based on the prequalification of the contractors and sub-contractors [31, 33, 59, 25, 26].

4.3 Motivation

Since the construction industry is craft-oriented, safety performance depends largely on workers' behavior and attitude [22, 87, 57]. Many researchers [26, 31] found that motivation is directly linked with wages and rewards at the worker's level. However, job satisfaction and peer pressure are also considered to motivate the workers for better safety performance [61, 58, 54]. An organizational approach for regular supervision will decrease the unsafe condition of the project sites and impact the overall safety performance of the sites [76, 5, 44]. Therefore, the organization often offers incentives to motivate their workers to ensure better safety performance. Motivation not only influences the relationship between workers and the site safety management system at the individual level but also impacts the association between the main contractor and the owner or subcontractors on a large scale [34, 49, 22, 36].

4.4 Productivity and financial aspects

Financial aspects include project size, project cost, contract price, method of procurement and quality of the output. Some sub-factors related to productivity like construction design error and rework influence the safety performance of the construction projects. Construction companies design their safety programs according to project size, cost, and the acceptance from owners [59, 22]. Clients are more concerned about the quality of materials rather than the quality of safety measures taken for the safety performance of the sites [59, 25]. Pekovic [18] found a positive correlation between poor quality and poor safety performance in the project sites. When the safety budget is not sufficient, other resource allocations like human resources, equipment, and technical support cannot confirm the safety condition of the projects [6, 16, 63]. Researchers found that productivity and safety performance support each other [38, 19]. For example, a toolbox meeting is a very important safety program that also plays a vital role in increasing productivity by reducing rework [31]. When the project cost is facilitated by a sufficient safety budget and contractors having sufficient safety competency are selected, the projects are expected to have better safety performance [57, 33]. The factors are concerned with financial aspects and productivity influence the relationship between the client and the main contractor which influence the safety system to project management [38, 68, 19].

4.5 Resources for safety

Safety resources equally refer to the safety personnel having technical skills and safety equipment like personal protection equipment (PPE), mechanical tools to protect the unsafe condition of the side, safe operation, and maintenance of the construction equipment [61, 69, 70]. Human resources are the most crucial sub-set of the factor related to resources [24, 29]. Raheem and Issa [31] found that the lack of proper use of PPEs promote unsafe behavior and decreases the overall safety performance of the sites. Besides this, measures to prevent falls from heights for other co-workers, safety signages, and safety bulletins are also important to ensure the safe condition of the sites [67, 68, 40]. Moreover, the safe operation of the construction equipment: following manuals, ensuring safe loads to lifting equipment, and confirming periodic maintenance impact the safety performance of the construction sites [46].

4.6 Working environment

The working environment includes the safe arrangement of facilities and working procedures that prevent the occurrence of accidents. Project management emphasizes to follow the procedures of materials storage, especially hazardous and flammable by providing proper training and signages [43, 74, 62]. Moreover, good housekeeping of the construction site enhances the safety condition that includes removal of waste, keeping the aisles free from obstacles to evacuate during any emergency period, and safe manual loading and unloading [54, 12, 70, 18]. Adding more, proper usage of safety signages to make aware of risky operations like fall protection, making safe earth excavation, and exposed electrical wiring is also important to improve the overall working environment [8, 29]. Beside this, the worker welfare facilities like sanitary facilities, drinking water facilities, and emergency medical facilities also influence the sites' safety performance [4, 35, 69, 42].

4.7 Work stress

Work stress includes work pressure, fatigue and mental disorder which tends to be reluctant to perform safety programs. Work stress impacts on not only the workers safety behavior but also overall safety climate of the sites [76, 92]. Memon, et al. [46] and Saunders, et al. [22] found that construction projects were unique because of their workmanship, project schedules, designs, method statements, contractors, subcontractors, owners and project locations. Moreover, to ensure profitability and productivity, the project is always running after a tight project schedule [38, 20]. But faulty design and rework are the barriers to maintain the work schedule that impact on the workmanship of the workers [66, 19]. Along with the over burden workload, peer pressure impacts the mental stress of the workers that deteriorates the safety climate of the site [73, 3, 9]. When the project runs behind schedule and costs overrun, contractors usually do not consider the safety programs as the project performance indicators. This makes the site management reluctant to perform safety programs and causes the project's overall safety climate to collapse. The frontline victim of the poor safety performance is the workers that impact the direct and indirect financial loss of the organizations [2, 23].

4.8 Safety management system

The safety management system starts from policy making procedures at top management level followed by preparing safety plans, implementing safety programs, forming safety committees, monitoring safety system, safety record keeping and site management procedures. Omar, et al. [73], Shin, et al. [87] and Yu, et al. [21] found that inclusive participation of all stakeholders was essential to make the safety management system successful. Top management commitment is the basic requirement to ensure safety climate in the organizations because it impacts the safety budget for resource allocation aligned with the project profitability [28, 50, 16]. In this connection the owner’s intention plays a critical role in ensuring the safety performance of the projects [25, 59]. Second tier management of the organization is responsible for preparing the effective safety plans and programs according to the requirement of project sites [58, 35, 24]. The project management team assesses the requirement of the specific types of safety programs to ensure the safety climate of the projects [24, 33, 66, 90]. Safety committee evaluates and monitors overall safety performance of the sites [73, 29, 47]. However, the formation of the safety committee is designed according to the safety policy of the organization. Moreover, developing the safety monitoring system is important to achieve safety goals that includes the record keeping system, evaluation system and review system of the existing safety programs [29, 31, 72].

4.9 Organization

The factor organization includes the sub factors size of the organization, structure of the organization, communication system, recruiting system, employee benefits, employee retention rate and leadership. Safety performance largely depends on the organization structure and its safety behavior. Guo, et al., [69], Rantsatsi, et al., [9] and Vashishta [37] found that the size of the organization impact the safety behavior and safety condition of the projects. Aksorn and Hadikusumo [7] confirmed that the small and medium scale organizations respond to construction safety were weaker than the large-scale organizations. Safety policy requires the inclusive participation of all types of stakeholders [33, 77, 73]. Some studies found that informal communication is more effective than the formal communication approaches for ensuring safety culture [30]. For ensuring an effective safety management system a justified reward system was recommended by many researchers [35, 11, 31]. Overall leadership approaches in the organization level influence to enhance the safety behavior of the projects that helps to maintain the safety culture of the organization [79, 80].

4.10 Accident records

Accident record is widely used to measure unsafe acts that requires to evaluate the safety behavior and safety condition of the construction sites [87, 57, 82]. Some studies include near accident data in accident record that make the accident database more effective decision-making tool [5, 44]. Therefore, some studies emphasized the documentation manual and procedures for better record keeping of the data related to accident frequency, types of

accident that happen frequently, responses of the workers and accident investigation procedures [70, 88]. Types of accident and its frequency depend on the project type, project safety culture and safety behavior of the workers [31]. Accident records are used not only for evaluating the existing safety performance of the sites but also the competencies of the safety personals [44, 6]. Hamid, et al., 2008 considered the number the accident as the tip of the ice burg to review the existing safety programs of construction sites. Therefore, the investigation process of the accidents and its recommendations were considered critical tools for designing safety plans for the projects [54, 91].

4.11 Safety attitude

Worker's safety behavior depends on the implementation of the safety programs [65, 50, 62]. Some researchers found that justified reward or benefit system positively impact the safety behavior of the workers that impact the safety attitude of the workers. Beside this, safety training programs also enhance the safety attitude of the workers that reflects on overall safety performance of the sites [52]. Though construction work is craft oriented, any negative human factors like workload, peer pressure decreases the mental condition of the workers and impact the safety responses for any unsafe act [10]. However, supervisor's skill and competency on implementing safety programs successfully can help to ensure the safety attitude of the workers [58, 26, 54]. Hardison, et al., [36] indicated the responsibility of the supervisors as an evaluation criterion to ensure overall safety attitude of the workers. For example, toolbox meeting is considered as an important tool to confirm the safety attitude of the sites [31, 88]. Moreover, different types of formal and informal communication regarding the safety condition also help to conform the safety attitude of the workers [84]. Some studies found that risk taking perception is also a critical factor to confirm the safety attitude of the workers. Risk taking perception of the workers largely depends on the demographic characteristics of the workers like age, location, race etc. [62, 60, 48].

4.12 Safety budget

Safety performance largely depends on an adequate safety budget and its proper utilization process [47, 2]. For ensuring safety budget, evaluating the requirement of the safety budget was considered the first step by Saunders, et al., [22]; Raheem and Issa [31] and Love, et al., [63]. As in some cases project budget does not have sufficient safety budget due to lack of fund arrangement from client side, the contractors and sub-contractors show reluctant to ensure basic safety performance. [2, 25, 59]. The competent site management provide first preference to utilize the existing resources by rearranging the available resources of the projects to ensure the safety performance of the sites and the second option was to procure the resources [68, 40, 87]. Memon, et al., [46]; Kukoyi and Adeboale [44] and Ji, et al. [62] incorporated the safety budget assessment in the safety monitoring system to evaluate the safety performance of the sites.

5. Holistic hierarchical framework

The construction management system has been discussed according to the micro level, project level, and organizational level in several studies [55, 58] where the micro level includes the workers' management, workers' productivity, and safety at individual levels [48, 59]. Guo and You, [93] found five system levels are there in macro-level patterns – inter-organizational, organizational, group, individual and working. However, the safety management system was discussed as integrated to construction management system by Guo, et al., [58] and Hinze, et al., [26] . The role of the different levels of the construction systems in the safety management system is influenced by some specific factors that impact the relationship between the different hierarchies of the construction management system. This study has developed a framework to show how the potential factors influence different hierarchies of the construction management system with the response from the questionnaire survey to the experts and confirms that a safety management system was an inclusive approach among all the levels of the hierarchy of the construction management system that means from government agencies to organizational, company level, project level, and individual levels.

At the government level, agencies related to occupational health and safety are responsible not only for the preparation of laws and regulations and for providing approvals [31, 21] but also develop the procedures for issuing approvals [32]. At the organizational level main contractors, sub-contractors and owners consider the government rules and regulations as the basic to ensure the safety performance in construction sites [35, 59]. In the holistic framework for construction safety, clients are the first point to initiate better safety performance in the projects. In this study, the experts also indicated the factors that influence the relationship between contractors and clients are regulations, financial aspects, and safety competencies. Moreover, safety regulations, safety competencies, resource allocations, working stress, working conditions, safety cultures, safety behavior, safety records, and safety program are the main factors to maintain the relationship between contractors and sub-contractors [46, 29].

The third level of the framework refers to the project level where the contractors develop the safety management system for the projects for the project team and the safety team of the sites [46, 26]. In the process of developing

and monitoring site safety systems, the factors like safety investment, working conditions of the project, resource allocation, safety climate, and safety programs [29, 49] are considered at organization level and project level. Finally, the individual level is the lowest level of the holistic framework indicating the worker's safety attitude and behavior. The safety performance of the site largely depends on the working process and the worker's individual attitude to the safety concerns [94]. Site safety systems operate by project management and the safety team are concerned about the factors : motivation [50, 61, 93], safety competency [25, 26], resource allocations [72, 44, 62], working environment [69, 60] , safety attitude [46], and safety records [75] to ensure the worker's safety behavior [23]. The characteristics of construction workers are different from other sectors [54]. In developing countries, workers in these sectors are not permanent and come from different other sectors due to many social and economic causes [7, 51]. Therefore, confirming safety behavior through proper training is a challenge for the project management team because of the job nature [52]. According to Mohammadi, et al., [95], figure 2 illustrates the framework for different hierarchical levels to show how the identified variables interact in the construction sector.

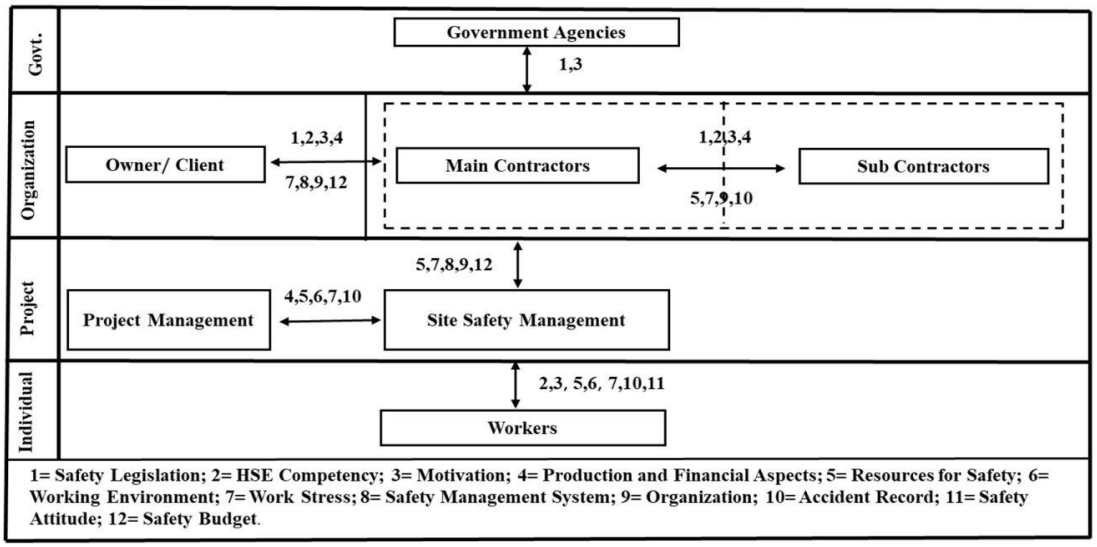

Figure 2. Interactions among factors of different levels at holistic hierarchical frameworks

6. Conclusion

In this study, a total of 12 main influential factors were extracted – safety legislation, competency in health and safety, motivation, productivity, and financial aspects, resources for safety, working environment, work stress, safety management system, organization, accident records, safety attitude, and safety budget. Following that, a comprehensive framework was developed to show how the key variables affected each level of the construction project hierarchy, including the governmental, organizational, project, and individual levels. This study will help the project managers understand the effect of different influential safety factors at different construction project hierarchies that impact the site's safety performance. Moreover, any researcher interested in working on the construction safety domain can use this study to get a clear understanding of the factors that influence construction safety in different levels of the project management hierarchy.

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