Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Role of organizational factors affecting worker safety behavior: a Bayesian Belief Network Approach

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Abstract

Several investigations on major occupational accidents are demonstrating interest in role of organizational factors. Investigations and evidences manifest that ''the root causes involved more than technical or human failures'' [1]. Thus, focusing on organizational factors is an important issue in safety as a means of mitigating accident in the workplace. First step for assessing the influence of organizational factors is to identify the relevant organization factors. Out of 22 factors identified from literature review, seven important factors were finalized for Thailand construction industry: communication, culture, management commitment, leadership, organization learning, empowerment, and reward system. At final phase, Bayesian Belief Network was used for handling the complex causality and providing the strategies to enhance the safety work behaviors. According to first alternative, 73.3% of safety work behavior was reached by manipulating management commitment, participation, learning and leadership nodes simultaneously. The second alternative accomplished about 74.6% of safety work behavior when the leadership, management commitment, participation and intention node were assigned to favorable state. For the third alternative, 77.7% of safe work behavior could be obtained by controlling leadership, management commitment, participation and perceived behavioral control node.

1. Introduction

Occupational accidents not only generate losses in property damage but also provoke a decrease in employee's morale, productivity, quality of products and services, public image, customer relations, and organization's reputation.

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In light of these economic and social costs, it is important that safety professionals and researchers require better understanding on the events preceding occupational injuries, as well as the relevant contributories that may influence in any individual's safety work behaviors. In Thailand, governmental and non-governmental agencies are active in development and promoting occupational safety in construction industry. Therefore, every project in Thailand has to be intergraded with safety program in day-to-day operations in order to increase safety performance. Besides that, there is still a need to reach the targeted outcomes, even though accidents in downward trend [2]. This indicates that these efforts are not adequate to handle at-risk work behaviors on the construction sites. It is important here to note that not only people are considered as contributing factors but also organizational factors shape the context that contributes to at-risk work behavior [3]. Thus, organizational factors have been recognized as the means of mitigating accidents in the workplace and improve the worker safety behavior.

2. Problem statement

Findings from several studies revealed and underpinned the idea that the majority of occupational accidents are caused by people rather than unsafe working environments [4,5]. Accordingly, findings indicate that approximately 80 percent of occupational injuries caused by at-risk behaviors while 15 percent caused by risk working conditions and the last five percent is inevitable [6,7,8]. This particularly brings attention to safety professional to recognize the importance of employee's behaviors as major root cause. The prominence of organizational factors in human error has been particularly acknowledged. Evidences from previous researches have supported the contribution of organizational factors on organizational safety performance. However, the effect of organizational factors in the field of work behavior in construction industry has hardly been examined. It is not easy to determine the implication on the improvement of the safety work behaviors in conjunction with the influence of organizational factors because of their complexities from the multiple causal relations between organizational factors, psychological precursors and safety work behaviors, especially in the complex construction safety scenarios. Thus, appropriate analytical approach should be capable of handling the complex causality from their interactions among organizational factors, psychological precursors and individual safety work behaviors within a built environment. Hence, inconsistency in the influences of causal relationships could be determined by various quantitative methods such as traditional inferential statistic or probabilistic model (Bayesian belief network). The achieved results and explanations should further enable the safety experts provide policy and procedures to increase safe work behaviors by considering the certain inferences of causative factors.

3. Methodology

Fig. 1. illustrates the research paradigm. Both qualitative and quantitative approaches have been used. After thorough literature review, a set of organizational factors have been identified. Through triangulation, key important organizational factors were finalized by expert opinion. After that causality analysis has been carried out using Bayesian belief network to develop strategies to improve the worker safety behavior.

4. Identification of organizational factors

The success or failure of the organization is reliant on the collaboration of all departments, identification of organizational factors, therefore, is based on perspective regarding on how an organization and its people cooperate within their environment. Therefore, the first step of systematic approach for evaluating the influence of organizational factors must sufficiently identify the key organization factors. Thus, a system theory has been adopted as a blueprint for a framework to identify and investigate the organizational factors. This theory provided the concept that attempt to integrate classical and human relation approaches. This phase utilizes the realism paradigm and the case study approach to decide how an organization and its people interrelate within their environment and to provide an illustrative framework because realism research is capable of "searching towards an understanding of the common reality of any system in which many people operate inter-dependently"[9]. Therefore, this study proposes 22 organizational factors including organizational culture, ownership, safety culture, leadership, personnel selection, reward system, resource allocation, communication, and management commitment, coordination of work,

formalization, organizational knowledge, empowerment, centralization, goal prioritization, organizational learning, technical knowledge, time urgency, problem identification, role/responsibilities, performance evaluation, and training.
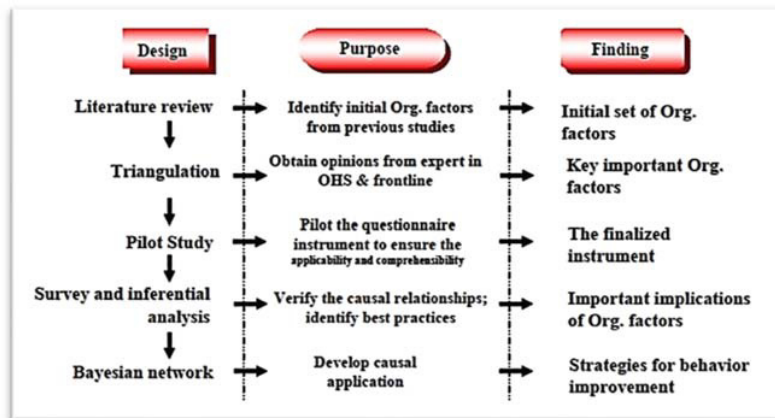

Fig. 1. Research Paradigm

5. Key organizational factors

Authors aimed to classify suitable organizational factors. It can be in terms of process or analysis approach [10,11]. According to the analysis approach offered by Osborn et al. [10], categories contain two main dimensions, i.e. organizational contingencies and intermediate outcomes. Organizational contingencies include four groups of organizational factors: governance, context, environment, and design. The latter category, known as intermediate outcomes, has four organizational factors: innovation, quality, efficiency, and compliance. This approach is founded on the organizational structure. Besides the organizational analysis approach, Jacobs and Haber [11] introduced a perspective to determine valid relationships between organizational factors and safe work procedure. It tries to determine how an organization works, versus how it is structured. For this reason, this study used the perspective of Jacobs and Haber [11] to determine how an organization and its people intermingle within their environment, since the success or failure of the organization is reliant on the relations of all departments. After focus group interviews with HSE experts and front line workers, following seven key important organizational factors were finalized.

5.1. Safety culture

Commonly, culture refers to the set of key values, beliefs, understandings, and norms that people of an organization share. Moreover, culture strengthens commitment for attainment of the organizational goal and establishes direction through explanation and also supports the standards of behaviors [12]. Sorensen [13] suggested that it is reasonable to consider organizational culture as application of the larger concept of culture, and safety culture could be represented as subset of organizational culture. Maximum HSE managers approved that safety culture development is important for reliably handling work behaviors and supporting safety awareness. Health & safety manager in Thailand said:

"When our people take risks for production targets or for any reason, frontline management investigates and considers how and why they do not follow procedure. This management action explicitly states that risk is unacceptable. These practices could govern work behaviors. On the other hand, if frontline management turns praise blind eye or gives praise when people accomplish tasks by violating safety rules, it means that frontline management has nonverbally stated that it is OK. This risk work behavior will continue."[14]

Results from inferential analysis indicate that safety policy consistently applied into specific actions and motivating subordinate to work safely has strong negative associations with at-risk work behaviors. Strong correlation values range from -0.61to -0.72. These strong inverse associations of safety culture development substantially implied that

motivating subordinate to work safely from management level could help reduce the occurrences of a-risk work behaviors in construction projects.

5.2. Communication

Numerous HSE managers intensely insisted that a two-way communication process establishes trust from consultative safety activities between different stakeholders in projects, because it can generate a shared understanding of risk and assistance to resolve conflicts that may arise about risk management decisions [15,16]. According to HSE manager in Thailand:

"Keeping open and honest communication greatly supports the risk management in a cross-disciplinary team as well as consultative. By breaking down the conventional hierarchical style, we can gain the benefit of our people's ideas and knowledge sharing. Such open communication builds commitment to our safety goal as well as also establishing trust. These help support compliance with risk control and any safety initiatives."[14]

5.3. Empowerment

Empowerment refers to the process that allows one to obtain the official authority and power. In general, this notion simply refers to process that provide subordinates with opportunities. Gibson [17] provided definition of empowerment as "individual's recognition, promotion and improvement of his abilities to achieve his own requirements, solve their own problems and mobilize resources to control their own lives by helping them to build a critical awareness of the situation and ease the proposition of a plan of action". Instead of trying to govern workers, empowerment is an approach that empowers the individual to regulate his environment and achieves self-determination [18]. For this reason, empowerment aims to establish work conception of increasing the involvement and motivation of frontline workers with moderate utilization of supervision as a control system and flat structure where decision-making authority tends to be downward. It is mentioned in the extensive literatures that the greater empowered workers are beneficial in mitigating the accident rate. However, in this study only 1st operatives testified the application of empowerment scheme. As per HSE manager in Thailand:

"Accordingly, workers are freely allowed to raise safety concerns, suggestions and has right to stop work whenever they found suspicious incidences. Peer-to-peer observations help us maintain safety awareness of workers. We also use the intrinsic rewards of meaningful work and the opportunity to learn and growth. Diversity of workforce on site will pool their area of expertise to achieve at procedures that are better than one could come up alone. Thus self-control of employee's work behaviors at workplace and continuous learning will be arrived."[14]

The most at-risk work behaviors have negative association with the actual implication of empowerment. The results of statistic inferences showed moderate correlation strengths between implications of empowerment and safe work behaviors.

5.4. Management commitment

Management commitment has been extensively acknowledged as a key ingredient of organizational success in competitive arenas regarding the attainment of certain aspects such as quality, production, job satisfaction and safety. Generally, exhibiting management commitment through its substantive actions helps improve employee commitment [19]. In particular, considerable findings found that management commitment has been exhibited to positively affect the work behaviors of organizational members, with remarkable examples originating from the occupational safety profession. Likewise, frontline respondents stated that they weigh the significance of safety concern from substantive action of top management [14].

The results of statistic inferences showed five of six key implications of management commitments, excluding the practices of resource allocations, have moderate correlation coefficients (r) with at-risk work behaviors. Their correlation coefficient values range from 0.5 to 0.6. In the light of these findings, it could be addressed that the construction projects where managements exhibit and implement the higher standard of commitment to occupational safety are most likely to lower occurrences of at-risk behaviors and improved safety work behaviors.

5.5. Leadership

The concept of leadership continues to evolve as the need of organizations change. As dynamic and reciprocal natures occurring among people, leadership plays an important role in influencing organizational members toward the attainment of certain goals. Reed [20] has defined leadership as the art of accomplishing change through people. The visible commitment and guiding example of leadership as modeling of the behaviors are critical for bringing about organizational safety. In particular, several researchers have put their attempts for investigating the relationship between leadership and occupational health and safety. Maximum HSE manager exposed that active role of leadership strongly inspires the safe work behavior of their subordinates. Safety performance will progress where the role of the leader is accepted and the leader makes employees admit the significance of safety [14].

The results of statistic inferences show that there is a strong negative correlation between encouraging frontline workforce discussion about safety by management and at-risk behaviors. Result from perception-based survey indicates correlation values in which their strength are greater than 0.57. The results of statistic investigations showed that three of eight key implications of leadership have strong correlation coefficients (r) with compliance behaviors to safety regulations and procedures. Thus, these strong associations between actual implications of leadership at workplace and safe work behaviors implied that implementing more participative and supportive style of leadership in construction projects could lead to better safety work behaviors at construction projects.

5.6. Organization Learning

Another vital feature to constantly sustain the employees' awareness and competency is organizational learning. Several problems have no ready-made solutions and require that members throughout the organization think in new ways and learn new values and attitude. Previous mistakes and failures are principally considered as elemental ingredients of learning and incident management. Case studies exhibited those HSE managers from organization that pays high attention to continuous learning vintages better performance. A number of HSE managers strongly agreed that learning empowers the creation of an organizational environment that encourages human development to meet the probability of organizational adaptability, and to avoid stability traps and self-satisfaction

According to results of statistical analysis negative association exists between regular rehearsal of training and at-risk work behaviors. Such correlation coefficient values range from -0.564 to -0.74. The slightly less correlation also found between reviews of proactive and preventive and at-risk work behaviors. In the light of these findings, it can be mentioned that the construction projects where implications of learning on board are most likely to lower occurrences of at-risk behaviors and promote safety work behaviors [14].

5.7. Reward system

In business arena, organizations extensively apply certain reward systems to motivate individuals and improve morale. Reward systems are conducted in different ways. Organizations commonly implement extrinsic and intrinsic reward to encourage and retain their people within the organization. Organization always endeavor motivation in their members to contribute to perform their activities in a safe manner. Such safety reward schemes are generally designed to handle risk behaviors and reinforce safe behaviors. HSE managers also claimed that "the most important issue is how strongly the worker is intrinsically motivated rather than motivated by tangible benefit." They propose a so-called "intrinsic safety motivation." One of HSE managers of construction organizations in Thailand said:

"Using merely 'carrot and stick' seems like seducing workers into complying with safety regulations as well as participating in certain safety initiatives. This will hardly cultivate internal motivation or consistently maintain safe work behavior. Instead, using intrinsic motivation coupled with extrinsic motivation yields better results. This makes workers recognize how important their well-being is to themselves and their families [14].

Besides selected significant factors, not all factors were acknowledged as important factors for assisting risk work behavior reduction, endorsing safety compliance or reassure safe work behaviors. Time urgency, centralization, goal prioritization and formalization were identified as less important in influencing risk work behaviors. Therefore

these were not recognized as contributing factors. Their consequences for safety might be considered as part of administration and received low priority with respect to safe work behavior.

Result of statistic inferences analysis indicated that there are strong positive associations between implications of reward system and safety work behaviors. Positive correlations exist between implementing reward schemes and safe work behaviors. In particular, a correlation of 0.664 exists between incentive for participation and compliance with safety regulation behaviors.

6. Network development

Bayesian Belief network (BBN) offers important capabilities to establish such complex causal relationships. This graphical network could determine and quantify complicated relations in accordance with specific evidence within built environment. For this reason, this study adopted this technique within aim to provide insight into influence of organizational factors and psychological precursors on safety work behaviors in construction projects as well as identifying practical combinations of key organizational factors to manipulate such factors that have the strongest influences on safety work behavior in complex construction scenarios. The main concerns with Bayesian network development is about lack of a clearly defined process. This study adapted the systematic steps of network construction from Sigurdsson et al.[21] shown in fig. 2.
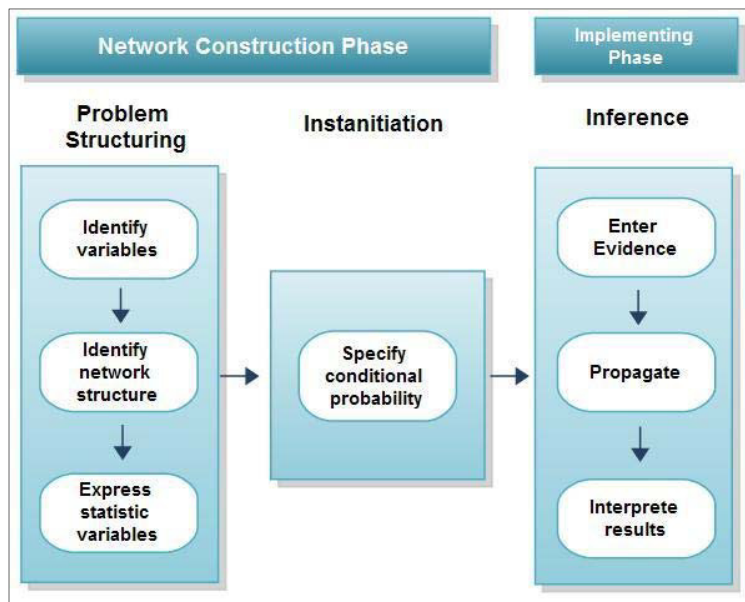

Fig. 2. Bayesian belief network process

To develop the Bayesian network in predicting safety work behaviors, and in order to obtain individual attitudes, beliefs and actual implications of organizational factors regarding occupational health and safety, a perception-based survey of frontline workers in Thai construction project was conducted. Building projects in Bangkok and surrounding provinces were participated as population samples for this analysis. According to system theory framework and how an organization works, seven out of twenty-two important organizational factors: communication, culture, management commitment, leadership, organization learning, empowerment, and reward system were finalized.

According to critical review of the behavioral literature, Theory of Planned Behavior could be one appropriate among work-related behavior models because it has particular characteristics: (1) consisting of precursor intent constructs covering the wide range of motivation, intention and behavior inaction, and (2) the proof of validity examining from a number of empirical studies in behavioral science e.g. Christian and Armitage [22], Johnson,

Musial et al. [23] ;Armitage and Arden [24] ;Armitage and Conner [25]. For this reason, this study adopted TPB as the reasonable basis for the development of BBN explaining safety work behaviors.

In Bayesian probability analysis, every entity requires assigning the prior conditional probabilities to the hypotheses. These prior conditional probabilities are typically acquired from knowledge of the prevailing circumstance. Due to limitation, the states at each node are kept at level 3 (Good, Average, Poor) to limit the number of surveys to possible limits. The developed BBN is shown in Fig. 3
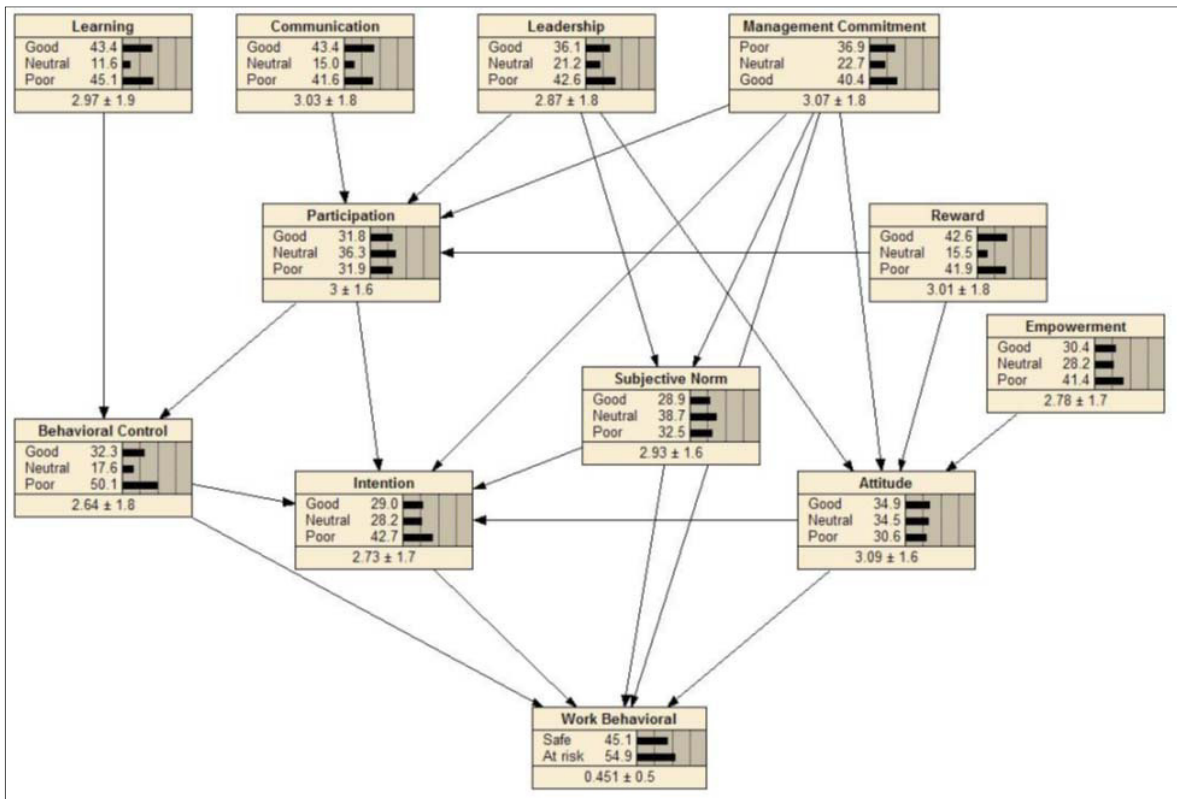

Fig. 3. Bayesian belief network

7. Results

7.1. Simple strategy

If implication states of management commitment change from poor to good, the probability of safety work behaviors ranged from 36.09% to 53.12%, which represents a sensitivity of 47.19%. This demonstrates that the favorable implications of management commitments seem essential to help improve safety work behaviors. Thus, in devising a simple strategy from manipulating organizational factor to improve safety work behavior, network recommend to particularly control the favorable implications of management commitments, which seem very essential to help improve safety work behaviors. Besides organizational factors, the psychological precursors of TPB archetype also play important roles in safety work behavioral enaction. As mediators, sensitivity of non-root nodes was higher than root nodes like organizational factors. In other words, safety profession should put their attempt to promote implications of such organizational factors that would lead to favorable state of psychological precursors.

7.2. Joint strategy

Considerable investigations are allowed to identify the appropriate combination of favorable states according to controlling variables. The obtained schemes enable safety professional achieve the attainment of high level probability of safety work behaviors. Realizing that there is an optimistic perspective in alternative scenarios, favorable state are assigned into potential variables, which might play an important role in establishing the safety environment and encouraging safe work behaviors. The presented alternatives highlight the useful implications that might lead to high probability of (wb=good) which are greater than 70%. According to first alternative, 73.3% of safety work behavior (wb=good) was reached by manipulating management commitment, leadership, learning and participation node simultaneously. The second alternative accomplished about 74.6% of safety work behavior (wb=good) when the leadership, management commitment, participation and intention node are assigned to favorable state (ls=good; mc=good; pa=good and in=good). For the highest alternative, 77.7% of safety work behavior (wb=good) could be obtained by controlling leadership, management commitment, participation and perceived behavioral control node (ls=good; mc=good; pa=good and pb=good).

8. Conclusion & recommendations

A number of optimistic scenarios are examined to determine the condition predictive ability of an early demonstrative guess in combination of implications regarding organizational factors. Due to limitation of time and budget, the sample size was limited but development of Bayesian belief application should incorporate more sample size in order to enhance the level of model reliability and robustness. Further research could be broadened to investigate other construction project categories. Apart from building projects, infrastructure and industrial projects have different scale and degree of technological complexity and to overcome drawback of perception-based survey, safety professionals should adopt direct observation method as means for collecting safety work behaviors.

Journal publications related with this article

1. Jitwasinkul, B., & Hadikusumo, B. H. (2011). Identification of important organisational factors influencing safety work behaviours in construction projects. Journal of Civil Engineering and Management, 17(4), 520-528.
2. Jitwasinkul, B., Hadikusumo, B. H., & Memon, A. Q. (2016). A Bayesian Belief Network model of organizational factors for improving safe work behaviors in Thai construction industry. Safety science, 82, 264-273.

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