Proceedings of 12th IOE Graduate Conference
Peer Reviewed
ISSN: 2350-8914 (Online), 2350-8906 (Print)
Year: 2022 Month: October Volume: 12

Prioritization of Factors Affecting Safety Work Behavior of Workers in Building Construction Projects: A Case Study of Kathmandu Metropolitan City

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Abstract
The construction industry, being one of the most labor intensive industries of Nepal, is considered to be a hazardous sector where accidents are very frequent and common resulting in significant losses. In a market oriented society, safety is not prioritized where the major objective is to accomplish the task with least number of resources and time. Therefore, this research study aims to prioritize the factors affecting the safety work behavior of workers in building construction sites. Two major factors influencing workers' safety behavior, namely personal and organizational factors were identified through extensive literature review and validation by industry experts. Quantitative strategies were used to prioritize the factors with the help of a structured questionnaire survey pretested with expert feedback. The identified factors were prioritized with the help of statistical methods and multiple iterations using Principal Component Analysis (PCA) and Relative Importance Index (RII) analysis. The results showed that all the factors are substantial regarding safety behavior. The appropriate grouping provided closer insights into the factors and presented the most significant factors in organizational and personal factors. It presents that the most significant organizational and personal factors are Cautionary/Warning Systems and Perception of Probable Risks by Workers respectively.The information and knowledge gained can be applied to the design and implementation of Occupational Safety and Health Systems for the construction industry in Nepal. It is expected that the findings of this research will enable the construction industry participants to help reduce construction safety issues, promote the safety culture and inspire further research in the area of construction safety in Nepal.

Keywords
Safety Behavior, Principal Component Analysis, Relative Importance Index, Occupational Safety and Health

1. Introduction

The construction industry is one of the largest industries in Nepal and plays a significant role in the social and economic development of the country.[1] As per the Economic Survey of Nepal 2020/21, the construction industry's contribution to economic growth is expected to be 9.81 percent, with a GDP contribution of 5.9 percent.[2] Nepal has a rapid demand for infrastructure development, making construction activities prominent and providing more opportunities.[1] As per the labor force Survey 2017/18, about 13.8 percent of Nepal's labor force is engaged in the construction industry, indicating that it is still a labor-intensive industry.[3] But in a market-oriented society, safety is not prioritized where the primary objective is to complete the task with the least number of resources and time.[1] Approximately 20 thousand workers are projected to be injured at construction sites yearly.[4]The construction accident rate in Nepal is severe compared to other countries.[5] A typical construction site is never the same since different groups of workers come and go as the project advances through its many stages. The complexity arising during the construction works can majorly hinder proper safety management.[6] Thus, the construction sector can be considered a hazardous sector where accidents are common and frequent, making it crucial to consider workers' safety behavior to minimize the risks.[7] Hence, identifying and analyzing the factors affecting the safety work behavior of workers in construction sites should be the first and foremost step towards building a proper safety culture and promoting safety practices in the Nepalese construction industry. This research intends to prioritize the factors affecting the safety work behavior of workers in building construction sites within Kathmandu Metropolitan city and assist in understanding the status of construction safety and, more specifically, workers' safety behavior in the building construction sector of Nepal.

2. Safety Behavior and OHS Status in Nepal

2.1 Safety Behavior

Behaviors are acts or responses of persons or things responding to a stimulus.[8] In simple words, it is anything a person does. In construction sites, it is an observable practice or actions by workers which matters the most for workers' safety.[8] Heinrich (1959) implied that accidents result from either unsafe behavior or a lack of action to end unsafe conditions. Workers' safety behavior must be carefully evaluated and, if required, corrected to eradicate their unsafe behaviors leading to accidents.[9] Since almost all aspects of the construction industry possess a behavioral component, safety behavior is fundamental.[10] It can be considered a total combination of commitment, participation, and communication in construction sites.[11] The behavior-based approach to OSH management is deemed the most effective way to lower accident rates.[7] Hence by determining the factors that improve workers' safety behavior, it will be possible to examine how safe behaviors may be instilled in the construction sector.[7]

2.2 Occupation Health and Safety status in Nepal

In the context of Nepal, there are limited legal provisions and protocols established defining the OSH policies. The provisions mentioned in the labor act 2075 are such that they apply to all sectors of workers, including the construction sector. There is no special attention given to this particular sector. The Nepalese construction industry is prevailed by rudimentary mechanization in the domestic sector and is predominantly labor intensive. Private construction companies are in the hoard to get the tender offer in the lowest bid limiting the budget and resources, which hinders the application of a safe working environment. Government authorities, unions, and other concerned bodies are rather ignorant than unaware of the OHS.[4] Although most of the contribution associated with the national economy is because of this particular sector, the government has offered little to uplift the OSH sector relating to construction. Shortcomings of the Government can also be stipulated by the lack of reporting and recording of accidents/incidents in this field. Only those incidents comprising fatalities or those gaining national media attention are reported to the concerned authorities, showing how existing health and safety data are inaccurate.[5] Construction Industry without any accident may not be practically possible, but it can be improved. Healthy human resources, efficient work culture, and fewer casualties can be achieved by improving the safety behavioral aspect.[5]

2.3 Factors influencing safety behavior of workers in construction (past studies)

Many past researchers have provided several factors that affect the safety work behavior of construction workers. The factors have been broadly divided into two main categories, organizational and personal factors. Manjula and Silva (2014) listed age, marital status, number of dependents, education level, knowledge on safety, experience, drinking habits, work-related pressure, work-mates safety behavior, and previous exposure to OSH accidents as personal factors. According to them, organizational factors include management commitment, provision of PPE, a Tidy site, safety training and awareness, site layout, OSH monitoring and feedback systems, and OSH incentives.[7] Also, Ismail et al. (2012) enlisted leadership, vision, direction, safety analysis, prevention planning under management factors and personal attitude, safety culture, positive groups, competency, awareness, and communication under personal factors.[10] Also, Rahim et al. (2008) grouped attitude, motivation, perception of risk, experience, laziness, emotion, and stress under personal factors; inspection programs, rewards, warning systems, safety policy, and training were categorized under organizational factors.[12] In this research study, these factors were validated and contextualized with relevance to the Nepalese construction industry with industry experts help.

3. Factors Identification and Prioritization

This research undertakes quantitative strategies to prioritize the factors affecting the safety work behavior of workers with the help of a structured questionnaire survey backed up by a rigorous literature review supported and validated by expert interviews.

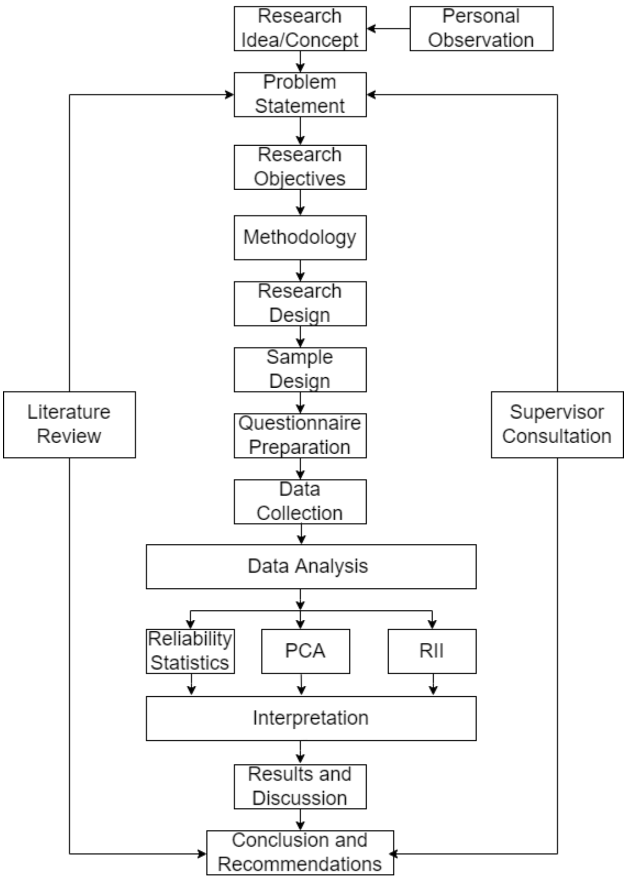

Figure 1: Methodology Flowchart

3.1 Identification of Factors Affecting Safety Work Behavior of Workers

The factors relevant to the Nepalese construction industry were identified and categorized through a rigorous and extensive literature review. These factors were further modified and contextualized with the help of construction industry experts. These factors are listed in Table 1.Based on the reviewed literature, a survey questionnaire was developed consisting of 5-point Likert Scale. The questionnaire was designed to be relevant to both the institutional/managerial participants and the workers and prevent any biased responses or duplication of information. For data collection, the respondents were divided into two groups/categories, i.e., Group A- institutional respondents/managers, and Group B -workers. The data from Group A participants were collected through in-person interviews and web-based questionnaires. In contrast, the on-site interview method was used to collect the data for the questionnaire from the Group B participants. The questionnaire was distributed to more than 70 construction companies currently involved in building projects (within Kathmandu). From one company, one superior, and one worker, 140 (N) respondents were available for further data analysis.

Table 1: List of Factors

Personal Factors	Organizational Factors
Perception of Probable Risks	Cautionary and Warning Systems
Mental State	OSH Incentives
Previous exposure to accidents	Safety Monitoring and Inspection
Individual Motivation	Safety Guidelines and Policies
Discomfort with Safety Instruments	Safety Awareness and Training
Intoxications	Management Commitment for Motivation
Hurry to complete	Penalizing Workers'
Indolence	Pressure From Management
Attitude	

3.2 Factors Extraction and Grouping Using Principal Component Analysis

Principal Component Analysis (PCA) is a well known approach for analyzing multivariate data. Pearson (1901) coined the concept, while Hotelling refined and developed it separately in 1933. PCA is a method of feature extraction or dimension reduction of a data set. It retains as much as possible of the variation present in the data set by formulating a new set of variables. These principal components are significantly ordered so that the first few retain most of the variation.[13] The organizational and personal factors are checked for reliability using the Cronbach α value, which refers to the internal consistency between all the factors considered during the survey. The PCA is done separately for the organizational and personal factors in SPSS software to extract important features from each in the form of principal components. For this, KMO and Bartlett's test results are analyzed to ascertain the possibility of conducting PCA with the given factors. Subsequently, the scree plot is analyzed to determine the number of components to be considered. The rotated component matrix is then generated and analyzed, which depicts the components' total factor loadings. Finally, the communalities are checked, which signifies how well the components represent the variables.[13]

3.3 Prioritization of Factors using Relative Importance Index (RII)

RII analysis is utilized in the subsequent stage to rank the extracted variables. Since the questionnaires prepared for data collection were on 5-point Likert Scale, the Relative Importance Index (RII) analysis deems suitable for determining the significance or ranking of factors.[14] As per Tam W. Y. & Le K.N., (2006),

$$\text{RII} = \sum w/(AN) \tag{1}$$

Where, w = weightage given to each factor ranging from 1-5 A = highest weightage N = total number of respondents

4. Result and Discussion

4.1 Reliability Analysis

Reliability analysis for 17 factors was conducted in SPSS and the value of Cronbach's alpha was found to be 0.709, i.e., there is 70.9 percent internal consistency between the 17 items. The range of value for Cronbach's alpha is from 0 to 1, with 0 representing no reliability between the items, whereas 1 representing high reliability or internal consistency. As the value is greater than 0.7, there is good internal consistency between the items.[15] This acceptance rule has been derived from the work of Nunally (1978).

4.2 Principal Component Analysis for Personal Factors

Table 2 shows that the KMO measure of sampling adequacy is 0.559, which ascertains the possibility of conducting PCA as the value is greater than 0.5.[16] Also, the significance value in Bartlett's Test of Sphericity is .000, which is less than 0.005, which rejects the null hypothesis that the correlation matrix is an identity matrix. Thus, the significant statistical test shows that the correlation matrix is not an identity matrix, and the factors are correlated and suitable for conducting principal component analysis.[16] From the graph obtained, there are 4 components with an eigenvalue of more than 1, so these 4 components will be considered factors per Kaiser Criterion (1961).

Table 2: KMO and Bartlett's Test Result

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.559
Bartlett's Test of Sphericity	Approx. Chi-Square	586.988

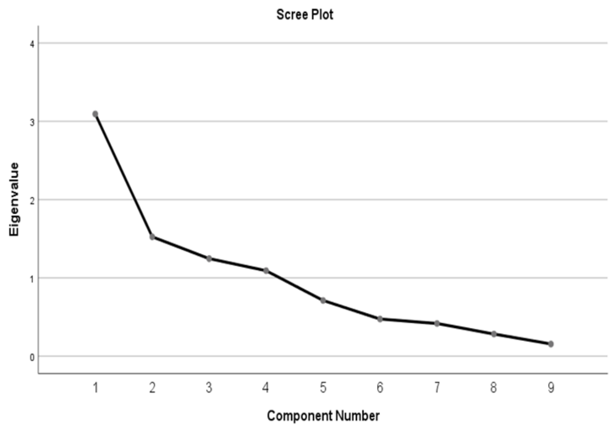

Figure 2: Scree plot for Personal Factors

Table 3: Total Variance

Components	1	2	3	4
Initial Eigenvalues				
Total	3.094	1.525	1.246	1.092
% Variance	34.378	16.945	13.848	12.132
Cumulative %	34.378	51.323	65.171	77.303
Extraction Sums of Squared Loadings				
Total	3.094	1.525	1.246	1.092
% Variance	34.378	16.945	13.848	12.132
Cumulative %	34.378	51.323	65.171	77.303
Rotation Sums of Squared Loadings				
Total	2.426	1.893	1.425	1.214
% Variance	26.95	21.034	15.833	13.486
Cumulative %	26.95	47.984	63.817	77.303

The cumulative percentage shown in the Table 3 explains the total variability of components. It also shows the total amount of variance accounted for in the construct by factors with eigenvalues above 1.0. These components have a variance of 77.303 % in total, meaning these four components explained 77.303 % of the total variability. The rotated components matrix shows the total factor loading of the components. Factor loading is simply the correlation of the specific variable to the respective principal component. The higher the value, the higher the correlation.[16] Table 4 also depicts the grouping of items into components. The communality values are high for all variables (i.e., closer to 1), which signifies that the components very well represent the variables.[16] The communality values are shown in Table 5. Hence, PCA shows the extraction of all the variables considered in the analysis. The factors were grouped, and a proper name was coined to represent

Table 4: Principal Components

Rotated Component Matrix				
Personal Factors	Component			
	1	2	3	4
Intoxications	0.916			
Indolence	0.759			
Hurry to complete	0.7			
Attitude	0.51			
Mental State		0.861		
Risk Perception		0.824		
Previous Exposure to Accidents			0.916	
Individual Motivation			0.535	
Discomfort with Safety Instruments				0.874
Extraction Method: Principal Component Analysis.				
Rotation Method: Varimax with Kaiser Normalization.				
Rotation converged in 7 iterations.				

Table 5: Communalities

Personal Factors	Initial	Extraction
Intoxications	1	0.857
Indolence	1	0.662
Hurry to complete	1	0.656
Attitude	1	0.672
Mental State	1	0.781
Risk Perception	1	0.829
Previous Exposure to Accidents	1	0.862
Individual Motivation	1	0.795
Discomfort with the Safety Instruments	1	0.844

and describe all the factors of the component. The grouping of personal factors as given by PCA is shown in Table 6. Prioritization of these factors was done using the Relative Importance Index Analysis. The results are presented in the Table 7.

Table 6: Personal Factors Grouping

Habitual Factors	Emotional Wellbeing
· Intoxications	· Mental State
· Indolence	· Perception of Risks
· Hurry to complete	
· Attitude	
Experience	**Discomfort**
· Previous Exposure to accidents	· Discomfort with safety Instruments
· Individual Motivation	

Table 7: RII of Personal Factors

Personal Factors	RII	Rank
Perception of Probable Risks	0.763	1
Mental State	0.737	2
Previous Exposure to Accidents	0.703	3
Individual Motivation	0.7	4
Discomfort with Safety Instruments	0.691	5
Intoxications	0.654	6
Hurry to complete	0.651	7
Indolence	0.631	8
Attitude	0.614	9

4.3 Principal Component Analysis for Organizational Factors

Similarly, from Table 8, we can see that the KMO measure of sampling adequacy is 0.741, and the significance value in Bartlett's Test of Sphericity is .000, which is less than 0.005, signifying that the factors are correlated and suitable for conducting principal component analysis. From the graph obtained, we can see that three components have an eigenvalue of more than 1, so these 3 components will be considered factors as per Kaiser Criterion (1961). The cumulative percentage shown in Table 9 explains the total variability of components. It also shows the total amount of variance accounted for in the construct by factors with eigenvalues above 1.0. These components have variance of 63.227 % in total, meaning these four components explained a 63.227 % of the total variability. Table 10 depicts the total factor loadings of the components and items grouped into components. The communality values are high for all variables (i.e., closer to 1), which signifies that the components very well represent the variables. The communality values are shown in the Table 11.Hence, PCA shows the extraction of all the variables considered in the analysis. The factors were grouped, and a proper name was coined to represent all the factors of the component. The grouping of personal factors as given by PCA is shown in Table 12.Prioritization of these factors was done using the

Table 8: KMO and Bartlett's Test Result

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.741
Bartlett's Test of Sphericity	**Approx. Chi-Square**	105.306

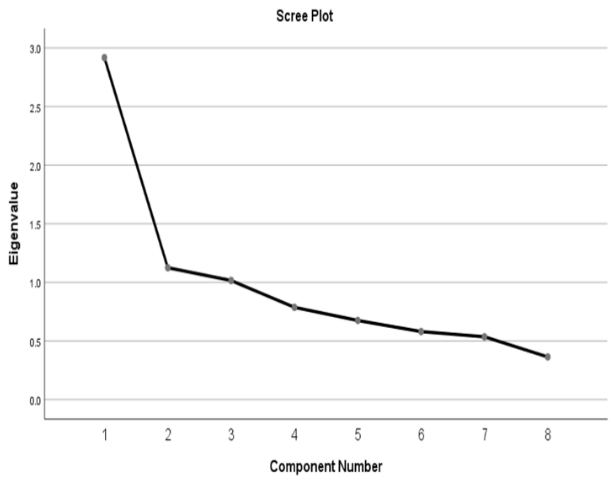

Figure 3: Scree Plot for Organizational Factors

Table 9: Total Variance

Components	1	2	3
Initial Eigenvalues			
Total	2.918	1.125	1.016
% Variance	36.47	14.061	12.695
Cumulative %	36.47	50.531	63.227
Extraction Sums of Squared Loadings			
Total	2.918	1.125	1.016
% Variance	36.47	14.061	12.695
Cumulative %	36.47	50.531	63.227
Rotation Sums of Squared Loadings			
Total	2.477	1.368	1.213
% Variance	30.963	17.101	15.164
Cumulative %	30.963	48.063	63.227

Table 10: Principal Components

Rotated Component Matrix			
Organizational Factors	Component		
	1	2	3
Management Commitment for Motivation	0.731		
Safety Awareness and Training	0.702		
Safety Guidelines and Policies	0.688		
Penalizing Workers	0.686		
Cautionary and Warning Systems	0.603		
OSH Incentives		0.91	
Safety Monitoring and Inspection		0.631	
Pressure from Management			0.865
Extraction Method: Principal Component Analysis.			
Rotation Method: Varimax with Kaiser Normalization.			
Rotation converged in 4 iterations.			

Relative Importance Index Analysis. The results are presented in Table 13.

Table 11: Communalities

Organizational Factors	Initial	Extraction
Management Commitment for Motivation	1	0.591
Safety Awareness and Training	1	0.673
Safety Guidelines and Policies	1	0.63
Penalizing Workers'	1	0.72
Cautionary and Warning Systems	1	0.57
OSH Incentives	1	0.829
Safety Monitoring and Inspection	1	0.605
Pressure from Management	1	0.774

Table 12: Organizational factors Grouping

Safety Management and Implementation	Safety Inspection
· Management Commitment for Motivation	· OSH incentives
· Safety Awareness and Training	· Safety Monitoring and Inspection
· Safety Guidelines and Policies	
· Penalizing Workers	**Leadership**
· Cautionary and Warning Systems	· Pressure from Management

Table 13: RII of Organizational factors

Organizational Factors	RII	Rank
Cautionary and Warning Systems	0.757	1
OSH Incentives	0.683	2
Safety Monitoring and Inspection	0.671	3
Safety Guidelines and Policies	0.651	4
Safety Awareness and Training	0.631	5
Management Commitment for Motivation	0.623	6
Penalizing Workers	0.583	7
Pressure From Management	0.494	8

5. Conclusion

This research study explores the area of construction safety, particularly to prioritize different factors that are the key influencers to the construction safety behavior of workers. This paper presents the factors affecting workers' safety work behavior, compiled from a rigorous literature review and validated by industry experts. The identified personal and organizational factors have been analyzed and prioritized with the help of statistical methods and multiple iterations. The results showed that all the factors are substantial regarding safety behavior. The appropriate grouping provides closer insights into the factors. It presents that the most significant organizational and personal factors are cautionary/warning systems and Perception of Probable risks respectively. The information and knowledge gained can be applied to the design and implementation of Occupational Safety and Health Systems for the construction industry in Nepal. Also, the insights gained from this study can help make decisions regarding the encouragement of workers to develop safety work behavior in the workplace. These findings will help understand the construction safety culture, and its utilization at the policy level will surely benefit the construction industry and the nation.

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