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A Case Study on the Mining Accidents Due to Unsafe Behaviour of Machinery Operators

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Abstract

The main objective of this study was to investigate the underlying factors contributing to unsafe behavior among machinery operators through questionnaires distributed among a sample of 48 operators. Data analysis conducted via SPSS software and Spearman analysis revealed several key contributors to unsafe behavior. These factors encompassed demographical aspects (such as age and educational background), job-related stress, dissatisfaction at work, social support, and the impact of addictive behaviors. Spearman correlation analysis further elucidated the interconnectedness among these variables offering insights valuable in mitigating unsafe behaviors.

Keywords: *Behaviour Influential Factors, Correlation Analysis, Reducing Unsafe Behavior, Spearman Analysis, SPSS Software, Unsafe Behaviour Operators*

1.0 Introduction

The mining industry is widely recognized for its unsafe working conditions, where accidents and injuries have persistently plagued the sector. Despite numerous management strategies and safety initiatives, the incidence of accidents remains disproportionately high compared to global standards. Machinery-related mishaps stand out as a significant segment within mining accidents, encompassing various hazards inherent in machines that, when encountered, can lead to severe injuries or fatalities. These hazards span structural risks such as sharp edges and projections, mechanical dangers like entanglement, crushing, and cutting, physical threats such as electricity, pressurized content, noise, and vibration, as well as extreme temperatures, and ergonomic challenges like awkward working postures, manual handling, and repetitive movements. Despite advancements in mining equipment and technology, the industry still grapples with a comparatively elevated risk of accidents. In response, safety conferences and industry bodies have emphasized the need to identify managerial, organizational, and environmental factors influencing accidents. Notably, worker behavior, encompassing collective values, attitudes, risk perception, and behavioral patterns, emerges as a pivotal factor highlighted for scrutiny and intervention.

In the late 1970s authors in[1] proposed that people's unsafe behavior and material insecurity led to the Occurrence of accidents. Chen believed that unsafe Behaviour Significantly deviated from the standard of human behaviors and finally led to unwanted delay misbehaviors or accidents. studies show that the most important factor influencing unsafe behaviors and accidents was an individual character's insufficient experience may be the most significant contributory factor for unsafe behavior[2,3].

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A study in Queensland, Australia revealed that irrespective of the mine types the major causes of accidents were due to skill-based errors performed by the operators, and indicated that mining accidents need to be analyzed from a human factors perspective too. After analysis of major accidents in China from 1980 to 2010, revealed that the percentage of human factors is about 96.5%, and the unsafe behaviour of human factors is the prominent cause of most of the accidents.

2.0 Problem Statement

Ensuring worker safety amid machinery operations remains a formidable challenge within mining environments. With a multitude of mobile mining equipment such as haul trucks, bulldozers, and excavators extensively used, it's not surprising that a significant number of accidents and injuries are linked to their operation. Studies underscore the industry's complexity, highlighting various contributors to accidents, notably the prevalence of unsafe worker behaviors[4,5]. As per the Indian Institute of Technology (ISM), Dhanbad, Jharkhand, an update as of 06/07/2022 revealed 48 accidents occurring between 2015-21 due to unsafe behaviors. Machinery accidents, primarily attributed to human error, often stem from inadequate risk assessment knowledge among operators. Factors like age and mining experience significantly influence these occurrences, with studies indicating a correlation between mining accidents and workers with less than 5 years of experience. For example, a fatal incident occurred in June 2018, where an untrained excavator assistant attempted to manipulate a massive boulder using the excavator bucket. Tragically, the excavator tilted, resulting in a fatal accident when the machine toppled over, causing severe injuries.

Unsafe behaviors not only contribute to accidents and injuries but also pose threats to mine production by creating hazardous situations, even if they don't result in immediate harm[6]. Addressing and controlling miners' unsafe behaviors in a timely manner is imperative. Failure to do so could significantly jeopardize worker safety and overall production, underscoring the critical need for proactive measures and interventions in mitigating unsafe practices.

3.0 Methodology

This methodology involves a full investigation of mining accidents and the elements that contribute to them. To understand the similarities and spot trends, the technique begins by looking at numerous mining incidents. The incidents caused by the usage of machinery and risky worker behaviour are then thoroughly investigated. Finding the elements affecting workers' risky behaviour is the goal of the analysis. An approach that can lower the frequency of such incidents is developed using this information. This methodology's other key elements are the questionnaire's design and Structural Equation Modelling (SEM). The SEM model is then put to the test, and the effectiveness of the suggested approach is assessed through data gathering. The approach is then tested to gauge its efficacy, and the outcomes are examined to yield important insights into the fundamental causes of mining accidents.

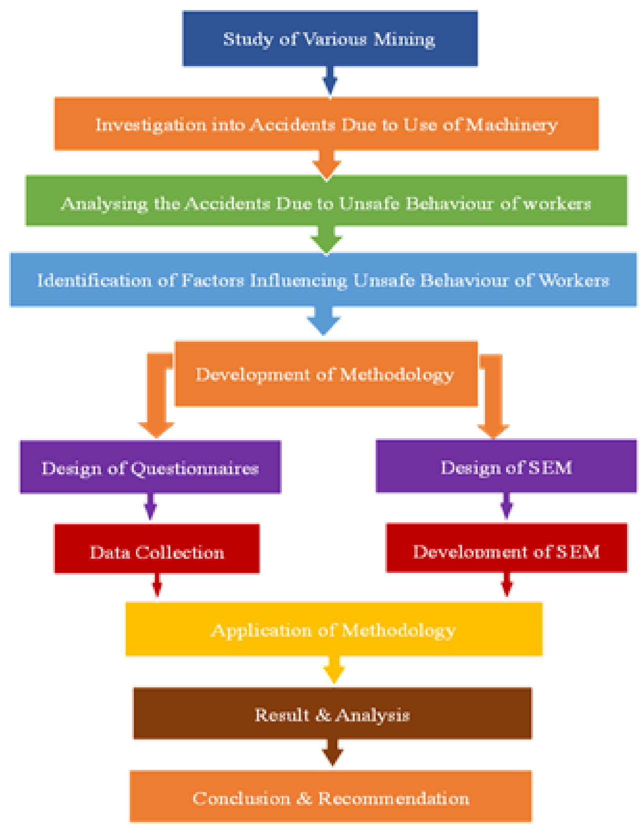

Figure 1. The methodology flow.

3.1 Development of Methodology

The research aims to construct a comprehensive multivariate statistical model and delineate the methodology necessary for its implementation. The methodology's detailed flow, illustrated in Figure 1, outlines the steps undertaken to investigate mining accidents attributed to workers' unsafe behavior. Existing literature has pinpointed several contributing factors to unsafe behavior, including demography, social support, job stress, addiction influences, job dissatisfaction, and unsafe behavior itself. Identifying and quantifying these factors are pivotal in comprehending and evaluating operators' unsafe behaviors. The study progresses along two primary paths: Examining and analyzing machinery-related accidents and injuries resulting from unsafe behavior. Delving into structural equation modeling to scrutinize the intricate relationships among influencing factors like demography, job stress, job dissatisfaction, social support, addiction's influence, and their sequential connections leading to operators' unsafe behavior. The questionnaire's design and data collection significantly shape the second path of the study. The essence of multivariate modeling lies in its ability to portray multiple variables within multifaceted scenarios, facilitating interactions among all variables during model runs with minimal errors[7]. This analysis endeavors to offer recommendations aimed at curtailing accidents caused by unsafe behavior.

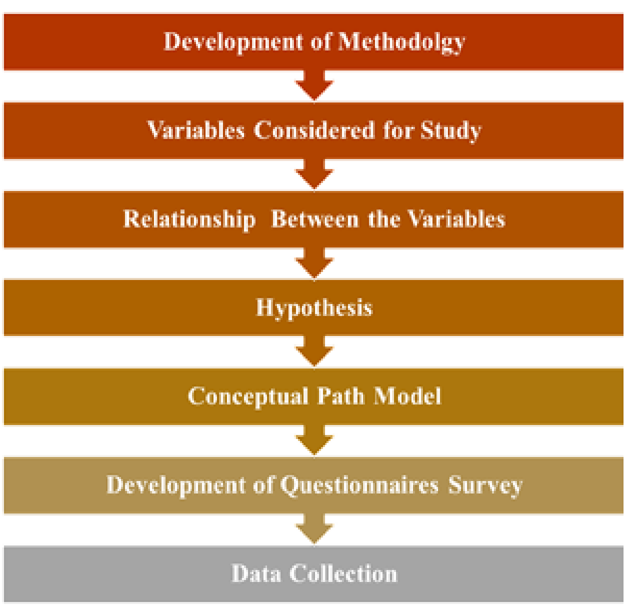

Figure 2. The development of methodology flow.

3.1.1 Based on the literature survey the variables are Considered

- Demography
- Job Stress
- Job Dissatisfaction
- Influence of Addiction
- Social Support
- Unsafe Behaviour

3.1.2 Hypothesis

- Demography is an independent parameter that directly influences unsafe behavior and indirectly influences unsafe behavior through Job stress and Job dissatisfaction.
- Social support is an independent parameter that directly influences unsafe behavior and indirectly influences unsafe behavior through Job stress and Job dissatisfaction.

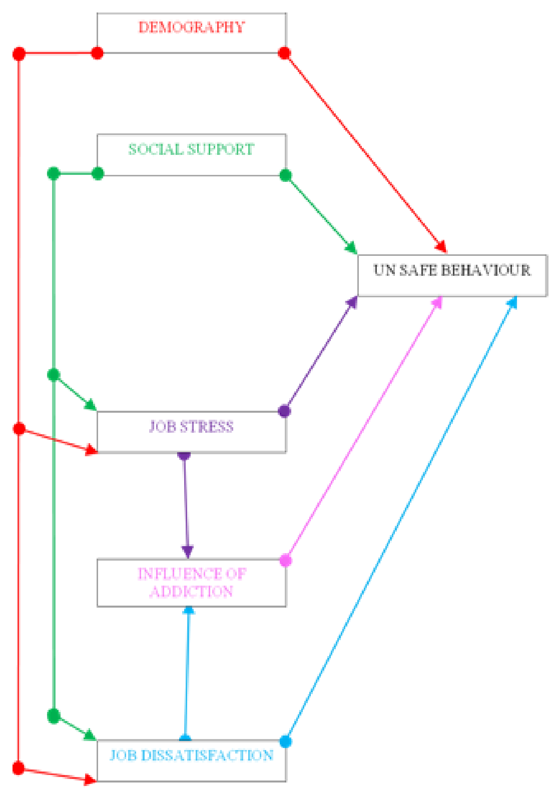

Figure 3. The conceptual path model.

- Job stress, influences of addiction, and Job dissatisfaction are all dependent parameter that directly influences unsafe behavior.

3.2 Application of Methodology

The survey method for this study is a Likert scale-based questionnaire. A representative sample of operators from several mines received the survey. The questionnaire includes questions about the behaviour of the operators, the safety culture of the mine, and accidents. The questionnaire was distributed in person to ensure a high response rate and address any questions the participants may have experienced.

3.2.1 Data Analysis

SPSS (Statistical Package for the Social Sciences) is a software program extensively utilized across academic, corporate, and governmental sectors for statistical analysis, data management, and report creation. Its user-friendly interface and robust functionalities make it a popular choice in various disciplines. This tool accommodates diverse data input formats such as Excel, CSV, and multiple statistical software programs. Furthermore, SPSS excels in data preparation, encompassing tasks like outlier handling and managing missing data. Its array of statistical methods includes descriptive statistics, correlation analysis, regression analysis, factor analysis, and multivariate analysis of variance. Additionally, SPSS provides data visualization tools like graphs and charts, along with alternative options for analysis[8]. Multivariate analysis denotes a collection of statistical techniques designed to explore datasets comprising multiple variables. These methods help in uncovering patterns, relationships, and the intricate structure of data involving numerous measurements. Among these techniques, multiple regression analysis stands out, allowing researchers to assess how independent variables impact and predict a dependent variable. This method evaluates the relationship between the dependent variable and several independent variables concurrently, aiming to identify significant predictors and measure their influence on the dependent variable's outcome[9].

3.2.2 Reliability Analysis

To ensure the reliability of the variables measured, Cronbach's Alpha coefficients are computed as an internal consistency reliability test. Cronbach's alpha measures how well a set of items (or variables) measures a single unidimensional latent trait[10]. When data have a multidimensional structure, Cronbach's alpha will usually be low. Cronbach's alpha can be written as a function of the number of test items and the average inter-correlation among the items. The values for Cronbach's Alpha of the variables are shown in Table 1.

Table 1. The Cronbach's alpha value

Variables	No of questions	Cronbach's Alpha value	No of the questions eliminated	Cronbach's Alpha value after validating
Demography	5	0.677	-	0.677
Social support	5	0.733	-	0.733
Job stress	5	0.474	1	0.712
Job dissatisfaction	5	0.302	2	0.711
Influences of addiction	5	0.596	1	0.618
Unsafe behaviour	5	0.714	-	0.714

The analysis showed that Cronbach's Alpha value ranges from 0.618 to 0.733 with the lowest value being the influence of addiction which is a dependent variable and the highest is social support which is the independent variable for this research. As for job stress, there is 1 item deleted, and for job dissatisfaction 2 items are deleted and for the influence of addiction 1 item is deleted to achieve a good Cronbach's Alpha value as shown in the table. A value of Cronbach's Alpha lower than 0.35 indicates low reliability while a value from 0.35 to 0.7 is acceptable and above 0.7 is considered high reliability.

3.2.3 Structural Equation Model

Structural Equation Modeling (SEM) stands as a vital statistical tool used to test complex theoretical frameworks by simultaneously estimating relationships among multiple variables. Within SPSS, SEM can be executed using either the specialized AMOS module or the integrated Structural Equation Modeling (SEM) module. Besides SEM, SPSS offers an array of statistical methods such as regression analysis, factor analysis, and cluster analysis. Additionally, it provides a suite of tools for data preparation tasks like cleaning, handling missing data, and variable transformations. The intuitive interface of SPSS contributes to its extensive application in academic, corporate, and governmental spheres. Amos, recognized as a robust SEM software, significantly aids in advancing research and theoretical development by extending traditional multivariate analysis methods, encompassing techniques such as regression, factor analysis, correlation, and analysis of variance.

3.2.4 Estimation of Goodness-of-Fit indices

Default ML estimation assumes the analysis of unstandardized variables. If the variables are standardized, then ML results may be inaccurate, including estimates of standard errors and model test statistics. This can happen if the model is not scaling invariant (its fit depends on whether the variables are standardized or unstandardized). Whether or not a model is scale-invariant is determined by a complex pattern of features, including how factors are scaled and whether certain parameter estimates are constrained to be equal[11]. One symptom of scale invariance when a correlation matrix is analyzed with default ML estimation is the observation that some of the diagonal elements in a predicted correlation matrix do not equal 1.0[12].

A (GFI) "Goodness-of-Fit Index" of 1 indicates a perfect fit. In general, a GFI value of 0.90 or higher is considered to indicate a good fit[13].

The Bentler (CFI) "Comparative Fit Index" is an incremental fit index that is also a goodness-of-fit statistic. Its values range from 0 to 1.0 where 1.0 is the best result. The CFI compares the amount of departure from close fit for the researcher's model against that of the independence (null) model[14].

The (RMSEA) "Stands for Root Mean Square Error of Approximation" Between 0 and 1, the RMSEA scale ranges, with lower values suggesting a better fit. An adequate fit is often defined as having an RMSEA value of less than 0.08 and less than 0.05, respectively. Nevertheless, depending on the model's complexity and other variables, some researchers have suggested that an RMSEA value of less than 0.06 or even less than 0.03 may be preferable[15].

The (NFI) "Normed Fit Index". ranges from 0 to 1, with values closer to 1 indicating a better fit, and an NFI value of 0.90 or higher is considered to indicate an acceptable fit.

3.2.5 Structural Model Result

The results of the structural model show that the Influence of addiction shows a major impact on unsafe behavior where the estimated value (b) = 0.526** and also social support (negative parameter) directly influences unsafe behavior, where the estimated value = -0.208 and social support has a major impact on job dissatisfaction which directly and indirectly influences unsafe behavior where the estimated value (b) =0.514**. Demography directly influences unsafe behavior, where the estimated value = 0.139, and indirectly influences unsafe behavior through job dissatisfaction (negative parameter) where the estimated value = -0.116. Job stress directly influences unsafe behavior where the estimated value = 0.180 and indirectly influences through influences of addiction where the estimated value = 0.028. Job dissatisfaction directly influences unsafe behavior where the estimated value = 0.133 and indirectly influences through the influence of addiction where the estimated value = -0.070 and job stress where the estimated value = -0.140. However, except for the influence of addiction, and social support

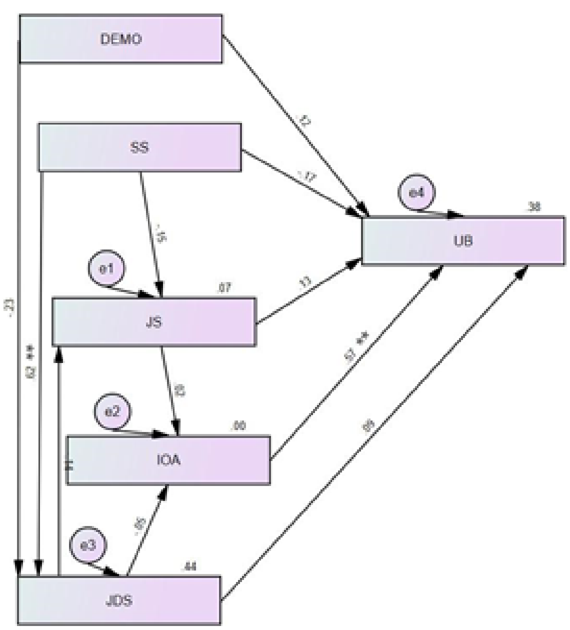

Figure 4. The SEM of variables influencing unsafe behaviour.

Table 2. The model fit value

Model Fit Index	GIF	CIF	NFI	RMSEA
Value	0.968	0.979	0.915	0.690

through Job dissatisfaction, the rest of the variables such as demography, Job stress, and job dissatisfaction show minimal impact on unsafe behavior.

It clearly shows that the influence of addiction and social support through job dissatisfaction has a major impact on unsafe behavior and it is evident that the majority of operators consume alcohol, tobacco, etc, during or after working hours, which results in unsafe behavior of the operators. Social support has a major impact on job stress, the majority of the operators are stressed because there is no support from the company which results in unsafe behavior of operators in the workplace.

4.0 Conclusion

The research effectively delved into the factors contributing to unsafe behavior by conducting a study within quarries in Karnataka and Tamil Nadu. A total of 48 samples were collected for this investigation. The findings highlighted two primary factors influencing operators' unsafe behavior: firstly, social support indirectly impacted unsafe behavior by exacerbating job dissatisfaction, and secondly, the direct influence of addiction on operators' unsafe behavior. Other elements like demographics, social support, job stress, and job dissatisfaction also showed some association with unsafe behavior, but their contributions were relatively minor. It's worth noting that factors such as demographics, job stress, and job dissatisfaction might exert less direct influence on unsafe behavior. However, it's important to acknowledge that these characteristics could still indirectly impact unsafe behavior through other channels or pathways. Further research is essential to thoroughly grasp their specific roles in influencing unsafe behavior.

5.0 Recommendation

The analysis underscores that addiction significantly contributes to unsafe behavior among workers. To mitigate this influence, employers are advised to establish a comprehensive policy addressing drug and alcohol use. This policy should encompass testing procedures, consequences for policy violations, and avenues for employees to seek assistance. Moreover, educating and training employees on addiction, providing support resources like counseling and assistance programs, fostering a safety-focused work culture, and promoting open communication and peer support among colleagues are recommended strategies. These steps aim to aid employees in overcoming addiction, thereby reducing the occurrence of unsafe behaviors and fostering a safer workplace environment. Additionally, the examination of mining accidents related to worker behavior highlights the indirect impact of social support on unsafe behavior through job dissatisfaction. Employers are encouraged to cultivate a supportive work setting that encourages camaraderie among coworkers and addresses factors contributing to job dissatisfaction, such as limited advancement opportunities, low autonomy, and unfavorable working conditions. Offering support programs like counseling services, employee assistance initiatives, and stress management resources can assist employees in managing job dissatisfaction and enhancing their overall well-being. Employers should also actively seek feedback from employees regarding the work environment and job satisfaction, taking necessary actions to address raised concerns. Investing in employee development programs and training opportunities further contributes to enhancing job satisfaction and reducing the likelihood of unsafe behaviors. Implementing these recommendations enables employers to foster a more supportive work environment, diminishing the indirect impact of social support on unsafe behavior driven by job dissatisfaction. This initiative aims to bolster employee well-being, diminish the occurrence of accidents due to unsafe behavior, and create a safer workplace environment for all employees.

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