The XXIXth Annual Occupational Ergonomics and Safety Conference
Seattle, Washington, USA
June 1-2, 2017

Association of Some Personal and Occupational Factors with Accidents at Continuous Miner Worksite: A Case Study

Amrites Senapati, Ashis Bhattacherjee, and Karthik Ravichandran

Department of Mining Engineering, Indian Institute of Technology, Kharagpur, India

Corresponding author's Email: ashisb2006@gmail.com

Author Note: Mr. Amrites Senapati is a research scholar of the Department of Mining Engineering and is working in the field of mine safety analytics. Dr. Ashis Bhattacherjee is a Professor of the Department of Mining Engineering and is working in the field of occupational health and safety, injury epidemiology and operations research for last 30 years. Mr. Karthik Ravichandran is a former graduate student of the department. Authors are thankful to the management of case study mine for their kind co-operation.

Abstract: In the underground coal mining sector of India, continuous miner technology is gaining wider acceptance since its first deployment in 2002 at Chirimiri Anjan Hill Mine of South Eastern Coalfields Limited. As the continuous miner worksite is an active production area, there are a number of prevalent occupational hazards which can lead to accidents/injuries. However, a very few information is available about occupational accidents associated with these hazards. This paper focuses on a case study mine located in the eastern part of India to identify the factors associated with occupational accidents at continuous miner worksite. A questionnaire based survey was conducted on a sample of 82 workers from the worksite. The questionnaire included several personal and occupational factors namely age, educational status, family size, marital status, job experience, training, alcohol consumption, risk-taking behavior, perception of working environment-related hazards, and geological/strata control-related hazards. The chi-Square test was used to check the association of 9 factors, which were considered in this study, with occupational accidents. The test revealed that the following 5 factors were significantly associated with accidents: family size, training, risk-taking behavior, working environment-related hazards, and geological/strata control-related hazards. Relative risk was also computed for all the 9 factors considered in this study. The following 5 factors were found to have significant relative risks: big family size (RR = 6.10; 95% CI 2.48–15.15), no training (RR = 3.89; 95% CI 2.02–7.46), risk-taking behavior (RR = 2.23; 95% CI 1.02–4.85), exposer to working environment-related hazards (RR = 2.46; 95% CI 1.00–6.13), and exposure to geological/strata control-related hazards (RR = 2.23; 95% CI 1.0 –4.85). Inferences drawn in this study can help the mine management to improve the safety performance at continuous miner worksite.

Keywords: continuous miner technology, chi-square independence test, relative risk, risk factors

1. Introduction

Accidents and injuries related to work are a major occupational health problem in most of the industrialized countries. Around 317 million work related injuries and 2.34 million work related fatalities, which are caused from work-related accidents and various types of diseases, occur each year in the world from a total population of 3 billion workforce (Staermose, 2013). The mining industry is one of the hazardous occupations in the world. For example, according to a study by Kisner (2000), the industries in the United States with the highest death rates per 100,000 workers were mining (30.3), agriculture/forestry/fishing (20.1), and construction (15.2) based on the fatality information during the 16-year period (1980 - 1995). Coal mines safety in India is a serious problem as the occupational injuries are common in the coal mining industry. The total number of fatalities for the years 2006 and 2015 were 78 and 69 and their rates per 100,000 workers were 36 and 19 respectively. Similarly, the total number of serious injuries for the years 2006 and 2015 were 861 and 281, and in terms of per 100,000 workers were 285 and 79 respectively. The fatal injury rates in Indian coal mines revealed that these figures are almost constant during the recent 10-year period 2007-2016 (DGMS standard note, 2015-16).

Indian coal mining industry has undergone a huge technological development during the recent years. The shift of technology during the last two decades, from the conventional underground mining to the mechanized underground mining and reduction in manpower through mechanization, has reduced the injuries and the continuous miner technology is most successful among such technologies currently being used in India. However, it is important to recognize that much remains to be accomplished to achieve the goal of a totally safe mine.

Traditional practice in several mining organizations in India generally involves reactive approaches to address the safety issues. Proactive approaches are necessary to further improve the safety standards in mines. Effective application of risk

assessment tools and other techniques is necessary to enhance identification and quantification of causal factors and to suggest effective solutions. Moreover, several research studies revealed that a majority of workplace accidents and injuries are attributed to the unsafe work practices of the employees rather than unsafe working conditions (Mullen, 2004, Ghosh et al., 2004). Due to aforementioned reasons human factors based safety management system can be a promising approach to further improve the workers' safety. This paper applies injury epidemiology as a risk assessment tool for the mining industry. The study determines the role of some personal and occupational factors which were associated with accidents at a continuous miner worksite.

2. Study Design

The design, which was used in this study, was a cross-sectional study. The survey was conducted on 82 underground mine workers working at the continuous miner district of the mine. The mine workers chosen for this study were randomly selected depending on their availability and interest of participation in the study. Out of 82 mine workers, 20 workers were involved in some kind of accidents. The protocol of this study included the following: (i) a request of participation of the mine management, and (ii) a questionnaire-based survey. A questionnaire, completed by the personnel interviews, included many factors among which educational status, family size, marital status, job experience, training, alcohol consumption, risk-taking behavior, perception of working environment-related hazards, perception of geological/strata control-related hazards, and occupational accidents were analyzed and summarized for the purpose of this paper. The questionnaires were filled up by conducting face to face interview with each worker separately. Each of the interviews required a time span of 15-20 minutes.

All of the variables were divided in two categories according to their descriptions. To capture the risk-taking behavior, eight items (negatively formulated) were used and responses were scored (yes=3, cannot say=2 and no =1) and summarized for total score. For categorization, 90th percentile of the total score of the non-accident group was used as a threshold value. The variable perception of working environment-related hazards was also captured through eight items. Workers were divided into two categories based on the worker's exposure to ≤ 50% or > 50% of the hazards listed under this factor. The variable perception of geological/strata control-related hazards was captured through four items and workers were divided into one of two categories exposed or not-exposed based on their exposer to at least one item. The occupational accident was the dependent variable with value 1 = Yes and 0 = No. Family size was divided into two categories: small family size (less than 6 members) and big family size (6 or more members). The variable job experience was also divided into two categories: high (≥ 15 years of experience) and low (<15 years of experience). All other factors were also divided into two categories. All the factors and their categorization criteria are presented in Table 1.

Table 1. Categorization of the factors

Factors	**No of categories**	**Coding Scheme for Statistical Model**
Occupational accident	2	0=No ,1=Yes
Education	2	0= Formal education,1=No formal education
Family size	2	0=Small (Members < 6), 1= Big (Members ≥ 6)
Marital status	2	0=Unmarried, 1=Married
Job experience	2	0= Less (years of experience <15), 1= High (years of experience ≥15)
Training	2	0= Formal training, 1= No training
Alcohol consumption	2	0= No alcohol consumption, 1= Regular alcohol consumption
Risk-taking behaviour	2	0=Low (score <18), 1= high (score ≥18)
Perception of working environment-related hazards	2	0= Not-exposed (exposure ≤ 4), 1=Exposed (exposure > 4)
Perception of geological/strata control-related hazards	2	0= Not-exposed (exposure < 1), 1=Exposed (exposure ≥ 1)

ISBN: 97819384965-5-4

To assess the effect of various factors on occupational accident, univariate analyses were carried out. The relationship between various factors and accidents were examined via the chi-square independence test. The risk of experiencing an accident for exposure to the various risk factors was measured through the relative risk. The IBM SPSS (Version-20) package was used for the statistical purpose.

3. Case Study

A case study mine from the eastern part of India was selected for the data collection. The mine was a large mechanized underground coal mine. The development of the mine started in early 1980s. The mine had eight extractable coal seams. During 1990s, the production from the mine was achieved through longwall mining technology. Continuous miner technology was introduced from 2007. Continuous miner technology had been successfully implemented in the mine with enhanced production and productivity. Besides the continuous miner technology, production was also achieved through the application of side discharge loaders (SDL) and load haul dumpers (LHD). The average production from the continuous miner section was around 1400 tonnes per day and the total production from the mine was around 2600 tonnes per day. The total number of workers employed in the continuous miner district was 1500. The total number of workers working in the mine was 3000.

3.1 Results

A total number of 251 injuries including 1 fatality, 24 serious injuries, and 226 reportable injuries was experienced from the mine during the last 5-year period. These injuries were experienced from continuous miner sections as well as SDL/LHD sections. The chi-square tests were performed based on the survey data of 82 mine workers to determine whether there were any significant association between the hypothesized risk factors and accidents which were experienced from the continuous miner district. The test results revealed that there were five significant risk factors: family size, training, risk-taking behavior, exposure to working condition-related hazard, and exposure to geological/strata control-related hazards. There was no significant association between accidents and level of education, marital status, job experience, and regular consumption of alcohol. Results of the chi-square test are presented in Table 2.

Table 2. Association of individual and occupational factors with occupational injury: comparison of two groups

Factors	% of Accidents	Comparison of two groups (p value)
Education		
No formal education	18.2	0.428
Formal education	26.7	
Family size		
Big (Members ≥ 6)	55.6	0.0001***
Small (Members < 6)	9.1	
Marital status		
Yes	24.7	0.315
No	22.2	
Job experience		
High (score ≥15)	28.8	0.321
Less (score <15)	17.9	
Training		
No training	17.1	0.0001***
Formal training	66.7	
Alcohol consumption		
Regular alcohol consumption	23.7	0.890
No alcohol consumption	25.0	
Risk-taking behaviour		
High (score ≥18)	36.4	0.038*
Low (score <18)	16.3	
Perception of working environment-related hazards		
Exposed (exposure > 4)	33.3	0.038*

Not-exposed (exposure ≤ 4)	13.5	
Perception of geological/strata control-related hazards		
Exposed (exposure > 1)	36.4	0.038*
Not-exposed (exposure ≤ 1)	16.3	

Level of Significance: *(p<0.05), **(p<0.01) and ***(p<0.001)

The crude relative risk provides a measure of the risk of experiencing an accident among the workers with the risk factor to the risk of experiencing an accident among the workers without the risk factor. The relative risk with 95% confidence interval for the various risk factors are given in Table 3. The following factors were statistically significant: big family size (RR = 6.10; 95% CI 2.48 – 15.15), no training (RR = 3.89; 95% CI 2.02 – 7.46), risk-taking behavior (RR = 2.23; 95% CI 1.02 – 4.85), exposer to working environment-related hazards (RR = 2.47; 95% CI 1.03 – 6.13), and exposure to geological/strata control-related hazards (RR = 2.23; 95% CI 1.02 – 4.85). The factors which were not statistically significant are the following: education, marital status, job experience, and alcohol consumption.

Table 3. Association of occupational and individual factors with occupational injury: crude relative risk and 95% CI

Factors	% Total	Crude Relative Risk	p value	95% Confidence interval
No formal education	26.8	1.47	0.444	0.55-3.91
Big family size (Members ≥ 6)	32.9	6.10***	0.0001	2.48-15.15
Marital status- yes	89.0	1.11	0.158	0.31-4.02
Less job experience (score <15)	34.1	1.56	0.338	0.63-3.85
No training	85.4	3.89***	0.0001	2.02-7.46
Regular Alcohol consumption	46.3	0.95	0.890	0.44-2.04
Risk-taking behavior (High, score ≥18)	40.2	2.23*	0.043	1.02-4.85
Exposer to working environment-related hazards (exposure > 4)	54.9	2.47*	0.049	1.03-6.13
Exposure to geological/strata control-related hazards (exposure > 1)	40.2	2.23*	0.043	1.02-4.85

Level of Significance: *(p<0.05), **(p<0.01) and ***(p<0.001)

4. Discussion and Conclusion

Out of nine risk factors that were initially assumed to be affecting the mine worker's involvement in an accident, only five factors were found to have significant association with worker's involvement in an accident. The accident rate was determined for each of the risk factors. The accident rate for the risk factors family size, training, risk-taking behavior, poor perception of working environment-related hazards, and poor perception of geological/strata control-related hazards were statistically significant. Based on the assessment of relative risk, the statistically significant risk factors were family size, training, risk-taking behavior, poor perception of working environment-related hazards, and poor perception of geological/strata control-related hazards. This information would help the mine management to focus on the problem areas and come up with prevention programs which are more pertinent to the continuous miner worksite.

In this study, the effects of each variables were considered individually. Therefore, the combined effects of the personal and occupational factors to the occurrence of an accident cannot be assessed through univariate analysis. Multivariate analysis is needed to study the combined effect of risk factors in an accident.

5. References

DGMS standard note,2015-16.

Ghosh, A.K., Bhattacherjee, A., & Chau, N. (2004). Relationships of Working Conditions and Individual Characteristics to Occupational Injuries: A Case-Control Study in Coal Miners. Journal of Occupational Health. 46: 470-478

Kisner, S. M. (2000). Work-related Fatalities in the United States: 1980-1995. Proceedings of the 5th World Conference on Injury Prevention and Control, New Delhi, 779

Mullen, J. (2004). Investigating Factors that Influences Individual Safety Behaviour at Work. Journal of Safety Research, 35: 275-285.

Staermose, T. (2013). Occupational safety and health: Global trends and challenges – An ILO perspective. Odisha State Safety Conclave, pp. 38-43.