

# Associations of Some Individual and Occupational Factors with Accidents of Dumper Operators in Coal Mines in India

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## Abstract

It is well known that individual and environment factors influence occupational accidents. This study assessed the associations of education level, family size, job experience, smoking habit, alcohol consumption, presence of disease, negative job involvement, job dissatisfaction, poor safety environment, job stress, risk-taking behavior, and fatigue, poor perception of rules and regulation, and emotional instability to occupational accidents of dumper operators in coal mines. The random sample included 135 dumper operators from two opencast coal mines in India. A questionnaire was completed by the personnel interviews. The data were analyzed using the adjusted odds ratios (ORs) which were computed with the logistic regression model using the SPSS package. The factors with significant adjusted odds ratios (ORs) found were: no formal education (OR 3.70; 95% CI 1.10–12.50), less experience (2.73, 1.01–7.39), negative job involvement (3.11, 1.10–8.79), poor safety environment (3.19, 1.15–8.83), job stress (4.08, 1.27–13.10) and emotional instability (4.97, 1.42–17.49). This information would help in implementing prevention programs to improve working conditions and to help dumper operators to develop positive psychological traits.

## 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 workforces [1]. The mining industry is one of the hazardous occupations in the world. For example, according to a study by Kisner [2], 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). The fatality rate in the USA mining industry exceeds the USA national industrial fatality rate [3]. Comparative raw data for all industries in the USA reveal that from a fatality standpoint mining has five times the average rate of all industries [4]. However, mining industry of the USA is experiencing a decline in number of fatalities and the fatality rates over the course of the twentieth century. Over the 30 years from 1978 to 2010, the number of fatalities has decreased by 70% and fatality rates by 25% [4]. The recent data during the five year period 2006–2010 reveal that all injury rates have decreased by 25%. Coal mines safety in India is a serious problem as the occupational injuries are common in the coal mining industry. The accident statistics reveal that the fatal and serious injury rates have not significantly reduced during the 10 year period 2001–2010. The total number of fatalities for the years 2001 and 2010 were 141 and 120 and their rates per 100,000 workers were 0.32 and 0.32 respectively. Similarly the total number of serious injuries for the years 2001 and 2010 were 720 and 449 and their per 100,000 workers were 164 and 108 respectively. The fatal injury rates in Indian coal mines revealed that these figures are almost constant during the recent 10 year period 2001–2010. However, the serious injury rates were high during the period 2004–2009 in comparison to the period during 2001–2003.

The current coal production in India is around 560 million tons per year; out of which 88% of the production is achieved from surface mines and only 12% of the production is from underground mines. 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 both

the mechanized opencast and underground mining and reduction in manpower through mechanization, has reduced the injuries. However, it is important to recognize that much remains to be accomplished to achieve the goal of a totally safe mine. Most of the surface mines in coal are mechanized mines using shovel-dumper combination for coal production; whereas, in some of the surface mines, equipment such as draglines, surface miners, and larger capacity machinery such as 270 tons dumpers are used. Surface mines, which are free from many of the hazards experienced in underground coal mines such as roof-fall, explosion, and inundation, would appear to be safer than underground mines. However, the accident experience in surface mines compared to underground mines shows a different trend. The fatality rate per 100,000 workers in surface and underground mines for the year 2010 were 52 and 32 respectively. Major causes of fatal accidents in surface coal mines are dumpers/trucks (55%), heavy earth moving machinery (17%), fall of persons and objects (7%), and side falls (5%). The immediate causes of accidents as revealed through all these statistics suggest that an-depth investigation is required to identify the factors associated with dumper operation injuries.

The present study aimed at assessing relationships of education level, family size, job experience, smoking habit, alcohol consumption, presence of disease, negative job involvement, job dissatisfaction, job stress, risk-taking behaviour, poor safety environment, fatigue, poor perception of rules and regulations, and emotional instability with occupational accidents of dumper operators in coal mines.

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## Background

Traditional approaches to managing workplace safety in mines have mainly focused on job redesign and the technical aspects of engineering systems. However, 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 [5,6]. Hazard identification and risk assessment is an important task for the mining industry which needs to consider all the risk factors at workplaces [6].

There are several factors responsible for the occurrences of injuries in mines. In several studies, some of the individual and occupational factors are claimed as potential risk factors of occupational injuries in mines [6,7]. Injuries are usually caused by the combination of the personal and impersonal factors, each of which may vary from situation to situation and may often be closely interrelated. The personal factors may include all individual factors namely demographic factors, socio-economic factors, behavioural factors, and health related factors and the impersonal factors include occupational factors, and management and supervision. The occupational factors may include various job hazards and environmental hazards. The present study mainly focuses on assessing the role of some of individual and occupational factors to the occurrences of incidents/accidents to dumper operators in coal mines.

A few epidemiological studies were carried out in coal mines to assess the relationships of some risk factors to occupational injuries. Kumar et al. [7] conducted a case-control study to assess the role of some causal factors to occupational injuries of mine workers. Specifically, the study assessed the relationships of job hazards, individual characteristics, and risk-taking behavior to occupational injuries of coal miners. The case-control study compared 245 male underground coal miners with injury during the previous two year period with 330 matched controls without injury during the previous five-year period. The study revealed that handling material-, poor environmental/working conditions-, and geological/strata control related hazards were the main risk factors.

In this study, the following individual factors are considered: education level, family size, job experience, regular alcohol consumption, smoking habit, presence of disease, negative job involvement, job dissatisfaction, risk-taking behavior, fatigue, poor perception of rules and regulations and emotional instability. The occupational hazards, which are considered in this study, are poor safety environment and job stress.

## Materials and Methods

### Study design

The design, which was used in this study, was a cross-sectional study on dumper operators in coal mines. The sample included 135 dumper operators who were randomly selected from two opencast coal mines of a mining company in India. Both the mines were using shovel-dumper combination for material handling in the face area. The annual production from Mine 1 and Mine 2 were 0.65 million tone and 2.5 million tons respectively. The study protocol included: a) a request of participation of the mine management and b) a questionnaire based survey which recorded, via personal interview, the hypothesized risk factors responsible for the occurrences of occupational injuries of dumper operators in coal mines.

The survey was conducted during the recent two year period. A standardized questionnaire was completed by the trained personnel

through face-to-face interviews. It included birth-date, height, weight, experience (years with the job), behavioral aspects, educational level (no-formal-education/formal education), regular consumption of alcohol, smoking habit (non-smoker/smoker), diseases, job-related hazards, and occupational incidents/accidents. The occupational physicians of the mines helped the research team to prepare the questionnaire for assessing the health status of the workers. The information on various diseases of the workers was checked by the interviewing team through the periodical medical examination records available at the mine medical service to verify that the good quality of the data was collected through the interview process.

### Statistical analysis

All of the variables were divided in two categories according to their descriptions. The behavioral and occupational factors considered in this study are the following: negative job involvement, job dissatisfaction, risk-taking behavior, fatigue problem, poor perception of rules and regulations, emotional instability, job stress, and poor safety environment. The scores were computed for each factor by summing the score of individual items. For categorization, 90<sup>th</sup> percentile of the score of the safe dumper operators for each trait were used as threshold values: 13 for negative job involvement, 9 for job dissatisfaction, 14 for risk-taking behavior, 10 for fatigue problem, 15 for poor perception of rules and regulation, 10 emotional instability, 20 for job stress, and 5 for poor safety environment to define the group at risk. The occupational incident/accident was the dependent variable with value 1=Yes and 0 = No. The variables alcohol consumption, smoking habit, and presence of disease were categorized into two categories with values of 1=Yes and 0=No. The variable job experience was divided into two categories with values of 1=less than 15 years and 0=15 years or more. Similarly, family size was divided into two categories with values of 0=less than 6 and 1=6 or more. Education was divided into two categories with values of 1=no formal education and 0=formal education.

To assess the effect of various factors on occupational incidents/accidents, univariate and multivariate analyses were carried out. The relationship between various factors and incidents/accidents were examined via the Chi-square independence test. Then, adjusted odds ratios (ORs) and 95% confidence intervals were computed via the logistic regression method. All the analyses were performed with the SPSS package.

## Results

The age of participants ranged from 18 to 60 years. The internal coherences of the questionnaire items of the factors were measured by Chronbach's alpha coefficients. They were as follows: negative job involvement (0.71), poor safety environment (0.85), job dissatisfaction (0.72), risk-taking behavior (0.71), emotional instability (0.78), fatigue problem (0.73), poor perception of rules and regulations (0.82), and job stress (0.84).

The overall incidence rate among the subjects included in the study was found out to be 32%. The relationship between various risk factors and incidents/accidents were examined via the chi-square test (Table 1). Table 1 provides the incidence rate according to various factors. Significant differences were observed for the following factors: level of education, family size, less experience in job, regular consumption of alcohol, negative job involvement, job dissatisfaction, poor perception of rules and regulations, emotional instability, poor safety environment, and job stress. For example, the incidence rate was significantly higher among the no-formal education group (46%) compared to the formal education group (26%). The difference in incidence rate was not found

Individual Factors	% Accidents	Comparison of two groups
<b>Education</b>		
No Formal education	46	0.01*
Formal education	26	
<b>Family size</b>		
Small family	28	0.15
Big family (≥ 5)	40	
<b>Job experience</b>		
Less experience (≤ 15 Yrs.)	43	0.02*
High experience (15 Yrs. & above)	23	
<b>Smoking habit</b>		
Smoker	37	0.36
Non-smoker	29	
<b>Regular consumption of alcohol</b>		
Yes	45	0.03*
No	26	
<b>Presence of disease</b>		
Yes	45	0.17
No	30	
<b>Negative job involvement</b>		
Yes	42	0.02*
No	24	
<b>Job dissatisfaction</b>		
Yes (score ≥ 9)	44	0.04*
No (score <9)	26	
<b>Risk taking behaviour</b>		
Yes (score ≥ 14)	44	0.22
No	30	
<b>Fatigue</b>		
Yes	42	0.30
No	30	
<b>Poor perception of rules &amp; regulation</b>		
Yes	50	0.09*
No	29	
<b>Emotional instability</b>		
Yes	57	0.007**
No	27	
<b>Occupational Factors</b>		
<b>Poor safety environment</b>		
Yes (score ≥ 5)	50	0.0005***
No (score <5)	20	
<b>Job stress</b>		
Yes	64	0.0004***
No	25	

\* statistically significant at p<0.05 , \*\* p<0.01, \*\*\* p<0.001

**Table 1:** Associations of Job Hazards and Individual Characteristic with Occupational Injury (N=135).

to be statistically significant for the factors smoking habit, family size, and presence of disease, fatigue, and risk-taking behavior.

Table 2 shows that significant relative risk was found for the factors no-formal education, less experience, regular consumption of alcohol, negative job involvement, job dissatisfaction, emotional instability, poor safety environment, and job stress. Six factors had significant adjusted odds ratios: education level (OR: 3.70, 95% CI 1.10-12.50), less experience in job (2.73, 1.01-7.39), negative job involvement (3.11, 1.10-8.79), emotional instability (4.97, 1.42-17.49), poor safety environment (3.19, 1.15-8.83), and job stress (4.08, 1.27-13.10). However, there was no significant association for the following factors: smoking (OR: 1.64,

0.54-4.98), family size (1.78, 0.64-4.99), alcohol consumption (1.80, 0.65-4.97), presence of disease (1.78, 0.43-7.37), job dissatisfaction (1.97, 0.68-5.69), risk taking behavior (2.66, 0.67-10.56), fatigue ( 1.49, 0.39-5.72), and poor perception of rules and regulations (2.63, 0.57-10.08).

## Discussion

This survey was a cross-sectional study on dumper operators who were randomly selected from two coal mines. In this study, efforts were made to eliminate selection bias of the sample. The case study mines belong to the same coal company and they were from the same geographical location to facilitate the study. It should be noted that all dumper operators were male. Face-to-face interview was appropriate in this study because most of the dumper operators were illiterate. The survey used validated questionnaires [8]. All the management staff from the mines and the dumper operators, who were contacted, participated in the survey. The study as a whole was well accepted by the dumper operators, the occupational physicians, and the mine management.

The present study revealed that the overall incidence rate among the dumper operators was 32% in the case study mines. The study also reveals that the dumper operators with no-formal education, regularly consuming alcohol, less experienced in their job, negative job involvement, job dissatisfaction, poor perception of rules and regulations, emotional instability, poor safety environment, and job stress had a higher incidence rate of accidents. The logistic regression analysis revealed that the dumper operators having no-formal education and less experienced in their job were at an increased risk of accident occurrence. Dumper operators having no-formal education are more likely to commit human errors as they are socially less prepared to learn safe driving practices as well as to follow safe working procedures. Many studies were conducted to see the effect of experience on accident rates. Root and Hoefer [8] studied job experience and accidents by analyzing workers compensation records. They studied approximately 270,000 work injuries. Their study revealed that 40% of all injuries were reported during the first year of employment and 50% of these injuries occurred during the first three months in the job. The dumper operators having negative job involvement, emotional instability, perceiving poor safety environment, and job stress were also at an increased risk of accident occurrence. Job involvement indicates

Individual Factors	Relative risk	95% CI	Adjusted odds ratio	95% CI
No-formal education	2.05*	1.28-3.27	3.70*	1.10 -12.50
Big family	1.43	0.88-2.34	1.78	0.64-4.99
Less experience	1.86*	1.12-3.09	2.73*	1.01-7.39
Smoking	0.79	0.48-1.30	1.64	0.54-4.98
Regular consumption of alcohol	1.36*	1.00-1.82	1.80	0.65-4.97
Presence of disease	0.66	0.38-1.15	1.78	0.43-7.37
Negative job involvement	1.80*	1.08-2.95	3.11*	1.10-8.79
Job dissatisfaction	1.70*	1.05-2.74	1.97	0.68-5.69
Risk taking behavior	1.49	0.83-2.67	2.66	0.67-10.56
fatigue	1.40	0.77-2.53	1.49	0.39-5.72
Poor perception of rules & regulation	1.70	0.99-2.99	2.63	0.57-10.08
Emotional instability	2.10*	1.30-3.39	4.97*	1.42-17.49
<b>Occupational factors</b>				
<b>Poor safety environment</b>				
	2.44*	1.48-4.04	3.19*	1.15-8.83
<b>Job stress</b>				
	2.61*	1.70-4.05	4.08*	1.27-13.10

\*statistically significant at p<0.05, \*\* p<0.01, \*\*\* p<0.001

**Table 2:** Association of Job Hazards and Individual Characteristics with Occupational Injury (N=135).

that workers are inclined to participate in the required activities of the organization. According to Vroom [9], job involvement exists when a person's feelings of esteem are increased by good performance and decreased by bad performance. A committed worker expects his work to be intrinsically rewarding, because he thinks that a work provides him an opportunity for self-expression. Therefore, he is very much personally affected by the whole situation, the work and the company itself [10]. Emotional instable persons are associated with frequent changes or swings in mood and emotions. Frone [11] suggested that negative emotional states and a lack of emotional stability may lead to lapses in attention or to higher levels of distractibility, thereby increasing the risk of injury. It is very well expected that the dumper operators experiencing an unsafe environment will experience more accidents. Moreover, preventive measures should be taken by the mine management to improve the working conditions. Dumper operators should also be trained to develop positive psychological traits.

The problem of stress in industrial setting has received increasingly greater attention in recent years. Harley and El Hassani [12] examined the relationship between stress and injuries in a sample of 335 truck drivers and 420 car drivers. The results of their study showed that "age", "gender", and "stress" accounted for a total of 35% of the accident or violation reports.

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