



Predictors of work injury in underground mines — an application of a logistic regression model

P. S. Paul

Department of Mining Engineering, Indian School of Mines University, Dhanbad 826004, India

Abstract: Mine accidents and injuries are complex and generally characterized by several factors starting from personal to technical, and technical to social characteristics. In this study, an attempt has been made to identify the various factors responsible for work related injuries in mines and to estimate the risk of work injury to mine workers. The prediction of work injury in mines was done by a step-by-step multivariate logistic regression modeling with an application to case study mines in India. In total, 18 variables were considered in this study. Most of the variables are not directly quantifiable. Instruments were developed to quantify them through a questionnaire type survey. Underground mine workers were randomly selected for the survey. Responses from 300 participants were used for the analysis. Four variables, age, negative affectivity, job dissatisfaction, and physical hazards, bear significant discriminating power for risk of injury to the workers, comparing between cases and controls in a multivariate situation while controlling all the personal and socio-technical variables. The analysis reveals that negatively affected workers are 2.54 times more prone to injuries than the less negatively affected workers and this factor is a more important risk factor for the case-study mines. Long term planning through identification of the negative individuals, proper counseling regarding the adverse effects of negative behaviors and special training is urgently required. Care should be taken for the aged and experienced workers in terms of their job responsibility and training requirements. Management should provide a friendly atmosphere during work to increase the confidence of the injury prone miners.

Keywords: mine safety; logistic model; case control study; occupational injury

1 Introduction

The mining of minerals is considered to be one of the most hazardous peace time occupations^[1]. It entails a constant struggle of human beings, armed with reason and resources, against the changing forces of nature. The mining environment, especially underground operation, is constrained by the absence of natural light, fresh air and open space and the undesirable presence of high temperature, humidity, dust, fumes, noise and rock stresses. Due to these constraints, the hazards and hazard potential inherent in a mine may trigger accidents unless sound and strong measures are taken to prevent them. The hazardous nature of coal mine operations can easily be deduced from the national statistics of mine accidents and injuries. For example, the fatality and serious bodily injury rates per 1000 persons employed for the years 2005 and 2006 are 0.30, 0.35 and 2.78, 1.84 respectively.

During the last 30 years, issues related to occupational safety in mines have attracted several researchers interested in investigating the causes of accidents and/or injuries and ways to control them. Early re-

search in the field tended to treat safety primarily as a technical problem that could be “engineered out” through improved design of workplace settings. These studies were mostly directed toward quantifying accident data (very often mine fatalities) by considering frequency, severity and incidence rate and identifying curative approaches such as machine modification, job redesign and miners’ training.

More recently, it is becoming widely accepted that technical approaches alone are inadequate to reduce accident rates to desired levels. That is to say, even when the purely technical problems associated with work settings are addressed, unacceptably high accident rates often persist^[2–4]. This has attracted researchers from many fields, such as those involving behavioral, social or organizational behavior, to explore alternative perspectives that take into account the context of personal and socio-technical factors when assessing the risk of occupational injury and illness to employees.

In this paper, an attempt has been made to evaluate the risk of occupational injuries to underground coal mine workers, controlling for their social, technical and personal characteristics.

2 Variables

The basic causes of high injury experience rates are unsafe conditions, unsafe acts, or both. Unsafe conditions may arise through insufficient mine design, unanticipated geological conditions, inadequately maintained equipment, inadequate supervision, or a combination of these factors^[5]. Unsafe acts mainly arise through behavioral causes. Unsafe behaviors are said to both directly and indirectly contribute to 90% of all workplace accidents and incidents. Given the importance of behavioral patterns in the accident process it is not surprising that safety improvements focused on individual behaviors have acquired popularity in the development of safety performance^[6–10].

Recent studies showed that an individual miner's obligation plays an important role in accident/injury causation in mines. Mine accidents/injuries can be associated with many factors including personal, social and technical factors^[11–13]. Therefore, based on the analysis of mining and non-mining industries^[14–24], the variables considered in this study are the following: demographics, personality, employment, safety-environment, social support, work-hazards, safe work behavior, and work-injury.

A critical review of the variables that brings out their significance to the present study is presented below.

2.1 Demographics

Demographic refers to the study of a population based on common characteristics such as age and experience. Age and experience have long been debated for their causal influences to work injury. Studies have reported both positive and negative^[14,25] relationships between age and work injury.

Experience represents the amount of time an employee has been engaged in his work. Conflicting results have been reported in the literature regarding this point. Prior studies have shown negative, positive, or no, relationship between experience and work injury^[14,17,26–28].

2.2 Social support

Social support can be broadly defined as the availability of help from supervisors, co-workers, and management in times of need^[29]. A considerable amount of evidence has accumulated to suggest that there is a significant positive relationship between poor management-worker interaction and work injury^[21]. Many studies have reported that supervisory support and co-worker support have a negative relationship with work injury^[30].

2.3 Work hazards

Several variables involving work hazards have been implicated in the occurrence of work injuries^[19–20,31]. 'Work hazards' have been measured in

the present study through the variables "physical hazards" and "production pressure". Prior research supports a positive relationship between physical hazards and work injury^[26,32–33]. Sanders and Pfeifer et al. stated that production pressure appears to lead to an increase in work injury. Since 'physical hazards' represents the actual physical condition of the workplace, it can be treated as a basic cause of accidents.

Production pressure can be related to meeting production targets. The causes of these pressures are considered extraneous and are beyond the scope of this study.

2.4 Negative personality

The negative personality of mankind has been implicated as a potentially important risk factor for work injuries^[18–19]. All the negative personality variables namely negative affectivity, impulsiveness, risk taking and depression have strong positive relationships with work injuries^[17,20–21,34–35].

2.5 Safety environment

The safety environment represents the organization's safety policies and practices prevailing at the mine site, including training. Workers who are aware of safety issues and well trained for the tasks they are to perform may avoid injury on a dangerous job whilst untrained and careless workers may be injured under the safest possible conditions^[21]. Proper safety practices lead to fewer accidents/injuries in mines. Safety equipment availability and maintenance have immediate affects on safety performance. Availability and maintenance of safety equipment are usually not good in high-accident-rate mines.

2.6 Job stress

Job stress results from a poor person-environment fit^[29]. The indices of role conflict and ambiguity developed by Kahn, Wolfe, Quinn, Snoak, and Rosenthal and Rizzo, House, and Lirtzman have been used in a number to studies to measure stress^[36].

2.7 Job dissatisfaction

Job dissatisfaction represents an individual's overall feelings towards their job. Prior studies have reported a positive relationship between the variable "job dissatisfaction" and work injuries^[16,21,37–38].

2.8 Safe work behavior

Unsafe behaviors are said to both directly and indirectly contribute to 90% of all workplace accidents and incidents^[39]. A safe work behavior is important since it helps workers maintain a safe work culture, which in turn reduce injuries.

2.9 Work injury

This variable is important as it is a direct measure of safety. It is also an indirect measure of the cost of

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