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"The Epidemiological Study and Role of Socio-Technical and Personal Characteristics on Work Injuries in Mines" A Critical Review

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Abstract- In earlier years when mining activities were modest in scale, safety problems too were simple. With the progress in exploitation of minerals, safety of persons employed became matter of concern. Occupational injuries in mines are attributed to many factors. Based on various literature review it may be come at common establishment that there are various factors responsible for work injuries in mines. Statistical tools have been developed in the light of epidemiological principals to see whether there is any role of some personal and impersonal factors in the occurrence of coal miner's injuries. In this review, an attempt has been made to identify the various factors related to work injuries in mines and to estimate the effects on work injuries to mine workers. An accident path model was developed to estimate the pattern and strength of relationship amongst the personal and impersonal variables in accident/injury occurrence. The case study results showed that there are sequential interactions amongst the sociotechnical and personal factors leading to accidents/injuries in mines. Amongst the latent endogenous constructs, job dissatisfaction and safe work behaviour show a significant positive and negative direct relationship with work injury, respectively. However, the construct safety environment has a significant negative indirect relationship with work injury. The safety environment is negatively affected by work hazards and positively affected by social support. The safety environment also shows a significant negative relationship with job stress and job dissatisfaction. However, negative personality has no significant direct or indirect effect on work injury, but it has a significant negative relationship with safe work behaviour. The endogenous construct negative personality is positively influenced by job stress and negatively influenced by social support.

Index Terms- Coal, personal factors, Impersonal factors, statistical tools, variables. Personal factors, Impersonal factors, Environment, Statistical tools.

I. INTRODUCTION

With the rapid industrialization and due to the increase in the complex technological operations, industrial safety and health have assumed great importance. The environment in the industries is entirely different from that of the agricultural or commerce and this has a large number of hazards associated with it. These hazards not only affect the individual but affect the whole surroundings including property, live, machinery and equipment. The government also had come up with various legislative measures to safeguard the physical health and occupational safety of the employees. Thus keeping the above factors in consideration a systematic and a scientific way of managing safety affairs have become imperative. It is more relevant when we talk about the mining industry, which is unique and different from the other industries, as it has to deal with many unknowns and has to work against the natural equilibrium. It therefore has a very high accident frequency rates. This occupation is considered to be one of the most hazardous one and this makes it necessary for the mining industry to have more effective accident prevention and safety programs. Since last decade, sea change in the economic, political and technological environment the world over, India is no exception. Lot of opportunities are also daunting challenges for the mining industry**.** Mining is a hazardous profession. Hence our endeavor to bring down the hazards by all available means to an acceptable level must continue. Work is still a serious problem. Creation of a nationally acceptable and internationally comparable mine safety program is a critical success factor for all safety programs being pursued in the country as far as mining industry is concern.

II. HISTORICAL DEVELOPMENT

History of mines safety in India is closely associated with the development of the Mines Safety Legislation and its updating from time to time as per the need of the mineral industry. Landmark developments in this area in India include the enactment of the Mines Act 1901. Thereafter, from time to time various rules and regulations have been framed to improve the safety standard of mines. The Workmen's Compensation Act, 1923 stated that management requires to pay compensation for injuries on the job regardless of whose fault caused the injury. The Mines Act 1952 reduced the working hours for all miners from 54 hours per week to 48 hours per week for all underground mines. In 1966, the Mines Vocational Training Rules were framed to provide basic training to new entrants and refresher training to mine workers with a view to make them aware of the dangers of workings in mines so that they can work safely. In addition, after nationalization of coal industry in 1973, several measures were taken such as formation of Pit Safety Committee and International Safety Organization in order to reduce accident rates and improve safety performance. Further, development and updating of the mines safety

legislation is being done from time to time in keeping with technological advances, incorporating the recommendations of national conferences on safety in mines, outcomes of various safety committee meetings, findings of research and development work by national research and educational institutes, and the recommendations of the Directorate General of Mines Safety (DGMS) through the issues of technical circulars to the industry from time to time based on experience of the directorate in enforcement of law, statutory inquiry into accidents and analysis of accidents. As a result of stringent government regulations, improved environmental conditions and increased safety management, the conditions in Indian coal mines have definitely become safer. However, it is important to recognize that much remains to be accomplished to achieve the goal of a totally safe mine. In this context, various approaches were undertaken to address the safety problems. The issues of injury prevention problems have been vigorously dealt with in Western countries.

III. CURRENT STATUS

In the 1980s the importance of human behaviour became widely recognized as a significant contributory factor in the aetiology of mine injuries. Sims showed, for example, that 55% of the haulage and transport injuries reported in the UK Chief Inspector of Mines Annual Report were directly attributable to "human failings" [1]. Human error has been identified as the major causative factor for injuries in mines in a study conducted by the former United States Bureau of Mines [2]. They concluded that while a few injuries are caused by a single factor, human error was the most significant contributing factor and accounted for 93% of the total injuries. Peake and Ritchie suggested in their study that while mechanical and environmental failures are major contributors to many injuries, human behavior plays a significant causative role and consequently must be addressed if any meaningful and long term reduction of mine injuries is to be achieved [3]. Although it is widely recognized that human error is implicated in the vast majority of occupational injuries in mines, the reduction of error potential has received relatively little systematic attention as an approach to injury prevention. Hopkins reported that both Government safety organizations and unions were quite optimistic on safety [4]. They focused on equipment and not on the act of people. Further, he stated that 95% of injuries occur because of the acts of people. At workplaces, workers do something that they are not supposed to do and are trained not to do so, but they do it anyway. Hence it is necessary that the orientation of injury prevention problems should give more focused attention on human behavioural aspects. Mason found that over the past fifty years there had been a dramatic improvement in the British mining industry's safety record due to engineering and mechanized improvement and achievements [5]. Simpson et al. found that the nature of injury causation in British collieries changed over the years and is now largely behavioural [6]. They found that engineering failures are no longer a major part of the causation of British mining industry's injuries. Human error, however, now forms the significant part of the causes of most injuries. Studies by the other researchers also indicated the role of human behaviour in mine related injuries [7]. Everyone on a mine site has a 'duty of care' around safety and health. This includes mine owners, employees, employee representatives, site managers, corporate and technical staff, contractors, consultants and government officers. The mining and extractive industries' duty of care also extends to the community in many ways [8]. A person under the influence of drugs or alcohol is more likely to cause a serious injury or death to himself and a co-worker, not to mention damage to company property [9]. Investigations into number of accidents has resulted causes as lack of awareness, lack of adequate training, issues regarding maintenance, design features [10].

IV. THE CAUSES OF OCCUPATIONAL INJURIES

The causes of injuries can broadly be classified into two categories–(i) human causes and (ii) environmental causes.

A. Human Causes

Human causes arise out of those deficiencies of an individual himself like unsafe performance, impulsiveness, emotional instability and day dreaming on a job. They also involve such physical inadequacies, violations of safety rules and regulations, absent mindedness arising out of fatigue and job dissatisfaction, and ignoring of safety devices. Job dissatisfaction often has a psychological origin, and may be due to anxiety, job stress, the monotony of the job on which a person is employed, frustration and inadequate incentives, unfair and incorrect method of selection and promotion, the absence of group harmony and social integration, bad leadership and ineffective organization and low social prestige. The frustrating situations include sudden or arbitrary withdrawal of desirable objects of certain privileges which were enjoyed by employees: the creation of distrust in an individual and his ability to work, the creation of distrust on the part of employees of a particular individual in the group; restrictions on opportunities for self expression, discrepancy between an aspiration and the ability to solve a problem. These situations affect the alertness of an employee, distract him from job, force to lose concentrations on the job, and lead to an injury. Several literatures are available which discussed the elements of human causes responsible for occupational injury.

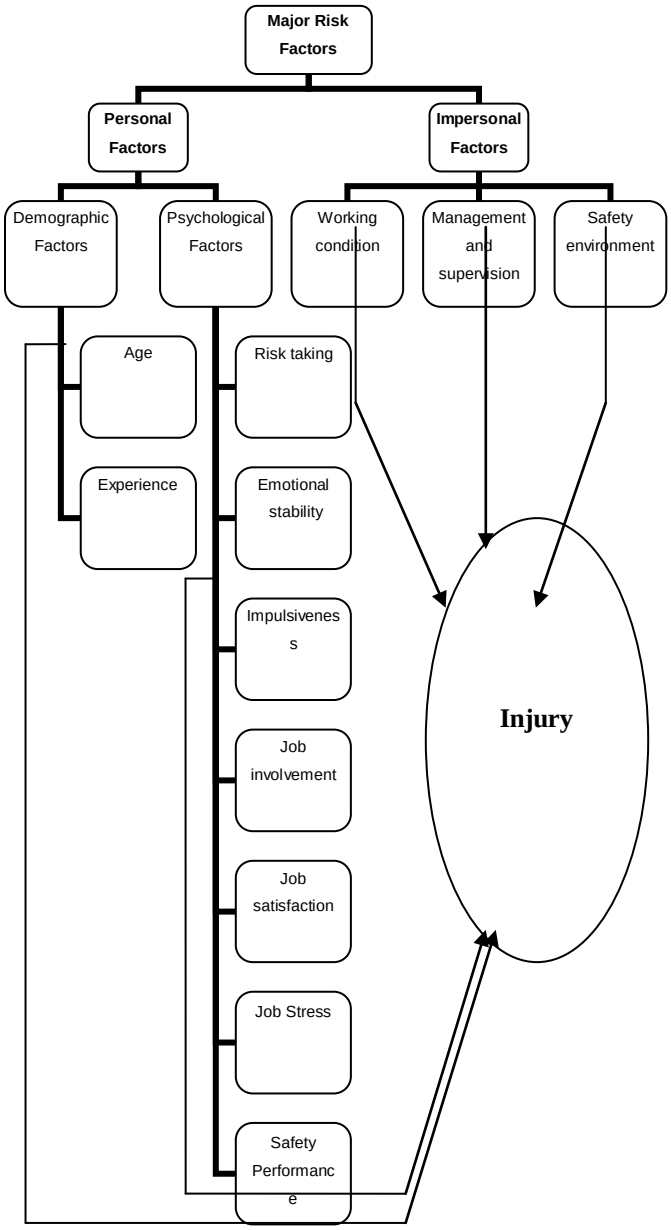

Fig. Major Risk Factors contributing hazards

B. Environmental Causes

Environmental causes arise of unsafe situational and climatic conditions and variations, such as bad working conditions, poor lighting and ventilation, and rough or slippery floors, unsafe storage facilities, unsafe plant layout, bad location, very long hours of work, unsatisfactory behaviour of dominating supervisors, unnecessary or excessive job related strain or tension, extensive noise and carelessness in the handling of sensitive materials like inflammable materials. Some other causes which also lead to occupational injuries are, alcohol drinking while on duty, poor housekeeping, violence and arson on the part of agitating employees. All these causes are physical, psychological or organizational and can be controlled to a great extent if properly looked into. Based on extensive literature survey the view of the researchers on the major environmental causes is cited in the following subsections.

V. CAUSAL RELATIONSHIP AMONG THE FACTORS

A. Working Environment – Job Satisfaction – Injury

Job dissatisfaction is one of the predictors of accident. Brief discussed two different models of job satisfaction: top-down, in which satisfaction is derived from how one interprets one's environment, and bottom-up, in which satisfaction is derived from experience of more positive job conditions [11].

B. Personality – Job Characteristics

Conceptually, several basic areas of research support the link between personality and perceptions of work characteristics. Research shows that individuals prone to the experience of positive emotions respond favourably to situations designed to induce positive effect, whereas individuals predisposed to experience negative emotions and negative self appraisals are less likely to respond positively to such situations [12]. Research has shown that positively disposed individuals rate characteristics of the task or the job as more enriched than do less positively disposed individuals [13].

C. Job Characteristics – Job Satisfaction

The job characteristics model proposed job satisfaction as one of the essential outcomes resulting from intrinsically enriched jobs [14]. According to this model, intrinsic work characteristics positively affect job satisfaction through a perceptual process. Two meta-analysis indicated a positive, moderately strong correlation between perceptual measures of intrinsic job characteristics and job satisfaction [15]. Though perceptual measures of job characteristics correlate more highly with job satisfaction than objective measures do, perceptual measures have been criticized for their potential contamination by common method variance [16]. It is noted, "An individual's view of himself or herself …with respect to self-evaluation (overall approval and acceptance of himself or herself), plays a central role in the process of interaction with the environment". The job characteristics literature has clearly shown that perceptual measures of intrinsic job characteristics do not perfectly reflect job complexity [17]. Judge et al. showed that job complexity was significantly related to job satisfaction [18].

D. Emotional state-Job Stress-Risk Taking Behaviour-accident

Hockey et al. discussing the effects of emotional state on decision making and risk behaviour, suggested that stress may directly affect performance by encouraging the use of shortcuts in cognitive processing, thus reducing mental effort [19]. Shortcuts such as attentional narrowing, reducing cognitive

complexity in problem solving, and a shift toward speed at the expense of accuracy may work by reducing the demand on stretched information-processing resources. It is not inconceivable that such changes may lead to an increase in errors. Clearly the effects of stress on cognitive performance and error, and thus on the possibility of an accident, require further research. In particular, it would be useful to clarify whether it is subjective perceptions of stress or reactions to the experience of stress that affect errors and accidents.

E. Antecedents of Job Satisfaction and Job Commitment

Job commitment refers to the extent to which an employee perceives that he or she is connected to a job and involves feelings or psychological attachment, independent of affect. There have been a few studies relevant to establishing the relation between job satisfaction and job commitment. Satisfaction and commitment were related but distinguishable attitudes. Further, he suggested that job satisfaction is associated with the aspects of work environment and thus will develop more quickly than commitment, which would require a worker to make a more global assessment of his or her relationship to the organization. A model developed by Steers describes the antecedents and outcomes of commitment [20]. According to this model, three main categories of variables influence commitment: personal characteristics, work experiences, and job characteristics. Although Steers did not specifically include job satisfaction as an antecedent, he did propose that it would probably influence commitment more, than would job characteristics. Similarly, it was developed a role taking model in their attempt to clarify psychological and structural determinants of the managerial commitment process. Their model identified three groups of factors as antecedents of organizational commitment. Personal attributes, organizational factors, and role-related factors (e.g., work overload, skill of subordinates). Although job satisfaction was not included in their analyses, they suggested that it might be an important predictor of commitment. In a conceptual turnover model, Mobley et al suggested organizational commitment as an attitude to be related to satisfaction and attraction to the present job, but no clear causal relation is hypothesized between satisfaction and commitment [21]. In a model, t was proposed that affective responses (job satisfaction, organizational commitment, job involvement) resulted from three major factors: (a) job expectations; (b) Job characteristics and experiences; and (c) job performance level. It was investigated a multivariate predictive model of organizational commitment and focused on the role of job level and organizational differences. The antecedents in their model included variables from each of Steers' categories. In an article, was used a structural equation approach to examine the causal antecedents and consequences of satisfaction and commitment within turnover models. Their causal model related personal and organizational characteristics to satisfaction, satisfaction to commitment, and commitment to turnover intention. Farkas et al. found that commitment and satisfaction may be either cyclically or reciprocally related [22].

VI. INJURY EPIDEMIOLOGY

A few epidemiological studies have addressed the role of personal as well as impersonal factors to examine whether these factors have significant statistical associations with occupational injuries in coal mines. Special attention has been paid to human behavioural factors responsible for mine accidents. Epidemiologic studies of occupational injuries have largely been descriptive in nature. These studies describe the distribution of injured persons (number and rates) usually in terms of person, place, and time characteristics and are useful for identifying hazardous industries, occupations and work situations. A frequent limitation of such studies is lack of information on the total population exposed and / or total time of exposure. Case-control or case-referent studies include injured persons as cases and uninjured persons as controls. By determining the percent of each group exposed to potential risk factors, one can estimate the relative risk of the injury under study exposure. In studies summarized eight case-control studies of occupational injuries. The criteria used to select these studies were: (i) use of case-control methodology, and (ii) cases and controls selected among persons injured and uninjured at work. The results of these eight studies suggest that the work practices and behaviours just prior to the injury (or personal factors within 12 hours before the injury) may be most important from an etiological perspective. However, this is difficult to measure because it entails interviewing the injured employee as soon after the injury as possible. Mortality of iron miners in Lorraine (France) was investigated on epidemiological principles. Epidemiological studies were also conducted to investigate occupational injuries in construction industries and railway firm in recent times [23].

VII. CONCLUSION

Although epidemiological investigation of occupational injury has become popular in USA, France, UK and Canada, during the last decades and that there is a growing awareness of it in the rest of the world, it is relatively a new area of research in India. So far injury epidemiology has been mainly applied in the chemical industry, roadway safety, railway safety, nuclear processing plant and construction industry. No extensive research in this area has been undertaken therefore required to study the same in coal mining industry in Indian scenario. The literature survey revealed that a wealth of information is available on the role of human elements in injuries and on ways to change unsafe behaviour. The methodology proposed is based on this information. It is important to determine what factors are causing injuries in mines so that appropriate preventive measures can be taken in coal mining industry.

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REFERENCES

[1]. Sims MT (1986). An ergonomics evaluation of the haulage and transportation of mining supplies. In: ECSC Final Project Report; Edinburgh: Institute of Occupational Medicine: p.1

[2]. Shaw BE, Sanders MS, Peay J (1989) Research to determine the contribution of system factors including human error in the occurrence of underground injuries. In: Proceedings XVI, Training Resources Applied to Mining, The Pennsylvania State University, University Park, August 14-16:9-23
[3]. Peake AV, Ritchie AJ (1994). Establish the primary causes of accidents in mines other than gold, coal and platinum. In: SIMRAC project report submitted to CSIR: Mining Technology (South Africa)
[4]. Hopkins A (1995). Making safety work. In: Allen & Unwin, Australia: pp.186
[5]. Mason S (1996). Measuring attitudes to improve electricians' safety. British Safety Journal: 166 – 178
[6]. Simpson G, Mason S, Glehn F (1996). The human element in rock engineering. In: Sangorm, Orange Grove, South Africa: pp. 9
[7]. Bhattacherjee A, Ray SC, Mukhopadhyay SK, Saran MB, Ghosh AK (2000). An investigation into personal and impersonal variates in coal mine accidents. In:Proceedings of the International Conference on Technology Management for Mining, Processing and Environment, 1-3rd Dec., 2000, IIT, Kharagpur: 297
[8]. Minerals Industry Safety Handbook, Edition 1, July,2002
[9]. Singh MK, Das SK, (2006) .Risk Analysis of dumper drivers for an opencast mine using a developed logistic regression model, Ist Asian Mining Congress, 2006,Kolkata
[10]. DGMS Tech. circular 03 of 2013, Ministry of labour and employment, Govt. of India
[11]. Brief AP (1998). Attitudes in and around Organizations. Thousands Oaks, CA: Sage.
[12]. Larsen RJ, Ketelaar T (1991). Personality and susceptibility to positive and negative emotional states. Journal of Personality and Social Psychology 61: 132 – 140
[13]. Necowitz LB, Roznowski M (1994). Negative Affectivity and Job Satisfaction:Cognitive Processes Underlying the Relationship and Effects on Employee Behaviours. Journal of Vocational Behaviour 45: 270–294
[14]. Hackman J, Oldham G (1980). Work Redesign. Reading, MA: Addison Wesley.
[15]. Loher BT, Noe RA, Moeller NL, Fitzgerald MP (1985). A meta-analysis of the relation of job characteristics to job satisfaction. Journal of Applied Psychology 70: 280–289
[16]. Glick WH, Jenkins GD Jr, Gupta N (1986). Method versus substance: how strong are underlying relationships between job characteristics and attitudinal outcomes?
Academy of Management Journal 29: 442 – 464
[17]. Spector PE, Jex SM (1991). Relations of job characteristics from multiple data Sources with employee affect, absence, turnover intentions, and health. Journal of Applied Psychology 76: 46–53
[18]. Judge TA, Bono JE, Locke EA (2000). Personality and job satisfaction: the mediating role of job characteristics. Journal of Applied Psychology 85 (2): 237-249
[19]. Hockey GRI, Clough PI, Maule AJ (1996). Effects of emotional state on decision making and risk behaviour. Presented at the Risk and Human behaviour (Economic and Social Research Council) Conference, York.
[20]. Steers RM (1977). Antecendents and outcomes of organizational commitment. Administrative Science Quarterly 22: 46–56
[21]. Mobley WH, Griffeth RW, Hand HH, Meglino BM (1979). Review and conceptual analysis of the employee turnover process. Psychological Bulletin 86: 493-522
[22]. Farkas AJ, Tetrick LE. (1989). A three-wave longitudinal analysis of the causal ordering of satisfaction and commitment on turnover decisions. Journal of Applied Psychology 74 (6): 855–868.
[23]. Chau N, Gauchard G, Siegfried C, Benamghar L, Dangelzer JL, Français M, JacquinR, Sourdot A, Perrin PhP, MurJM (2003) Relationships of job, age, and life conditions with the causes and severity of occupational injuries in construction workers. International Journal of Occupational and Environmental Health

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