



## A General Framework For Prioritizing Research To Reduce Injuries And Diseases in Mining

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**To cite this article:** Russell Levens (1998) A General Framework For Prioritizing Research To Reduce Injuries And Diseases in Mining, *Human and Ecological Risk Assessment*, 4:6, 1285-1290, DOI: [10.1080/10807039891284668](https://doi.org/10.1080/10807039891284668)

**To link to this article:** <https://doi.org/10.1080/10807039891284668>



Published online: 03 Jun 2010.



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## **A General Framework For Prioritizing Research To Reduce Injuries And Diseases in Mining**

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### **ABSTRACT**

A strategy for prioritizing mining health and safety research by evaluating the potential for risk reduction through interventions is proposed. Mining has one of the highest incidence rates of injury and disease found in major industries. The main premise of this paper is that often the best opportunities to reduce these rates are not revealed by retrospective analysis of injury and illness data. Instead, a proactive approach is needed that accounts for risks to specific hazards that can be abated by engineering or behavioral interventions.

The process proposed here begins with development of prospective interventions. The degree of reduction in risk to be expected from an intervention then is determined from statistics on the mining worker population, the expected degree of success of the intervention, and the expected change in the severity of injuries resulting from the intervention. Three disparate mining health and safety concerns are presented to demonstrate common problems in assessing risks of injury and illness and describe additional data needs. Information on events preceding injuries and illnesses and more detailed demographic data on the mining work force are needed to analyze injury and illness data more precisely. Detailed information on exposure to specific hazards is necessary to evaluate the potential for an intervention to reduce risk of injury or illness.

**Key Words:** injury, illness, mining, risk assessment, prioritize

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## INTRODUCTION

Recent initiatives such as the Government Performance and Results Act (GPRA) mandate directing research to achieving public goals. For the Office for Mine Safety and Health Research of the National Institute for Occupational Safety and Health (NIOSH), GPRA means directing research to reducing risks in mining.

Prioritizing research should do more than differentiate among risks to different populations. A proper strategy should also distinguish the degree to which risk is reduced. In this paper, a framework of risk analysis is proposed that considers the effectiveness of selected interventions in reducing mining health and safety problems.

There are many ways to conceptualize risk. Each concept is valid, and each is responsive to alternate objectives. In its purest form, risk is a function of the probability of the occurrence of a given undesirable event and the severity of the outcome of that event. Risk assessment can be used to assess changes in risk resulting from research interventions. This is a step that is often missing from a more formal framework, but is a key that ties risk assessment more closely with risk management.

Three mining research issues are examined to illustrate the proposed framework, to identify difficulties in comparing risks, and to identify data needs.

## INJURY HAZARDS IN MINING

Mining has one of the highest incidence rates of injury and disease found in major industries. Hazards in mining include long-term problems, such as roof falls in underground mines, as well as emerging problems arising from changes in technology or changes in mining methods. Sprains and strains resulting from physically demanding work are common in mining, but are rarely life-threatening, whereas fires, explosions, and catastrophic collapses of underground mines occur much less frequently, but have the potential for killing many workers. Illnesses such as hearing loss and silicosis have significant permanent affects on the quality of life of miners.

The diverse nature of mining hazards and the resulting injuries and illnesses makes assessing risks difficult. Different frequencies of occurrence and different degrees of injury need to be compared in order to prioritize research based on risk. Estimates of time spent conducting specific tasks are necessary in order to evaluate the potential for interventions to reduce risk.

## RISK ASSESSMENT OVERVIEW

Risk assessments can be used to make decisions on allocation of resources, setting and enforcement of regulations, inspection priorities, and, in the case addressed in this paper, setting research priorities. Methods of descriptive epidemiology are commonly used to compare injury incidence rates by place,

time, and population. This information, in combination with a measure of the consequences of injuries, is a common basis for risk assessment.

Risk can be formally defined as the probability of an injury or illness multiplied by the severity of the health effect (McCormick, 1981; Brauer, 1990). Probability is usually expressed as the relative frequency of an event. Severity can be expressed in various ways, including by number of days lost, number of fatalities, medical cost, or a combination of these measures.

Problems in comparing injury risks arise because it is difficult to assess exposures to hazards or to compare the severity of a disabling to a temporary injury or a fatality to an injury. Proxies for exposure, such as total employment in a given industry or occupation, are usually substituted when exposure to specific hazards is not known. However, exposure, defined as the actual time involved in a specific hazardous task, is needed to evaluate the potential degree of risk reduction resulting from proposed interventions. Surveys to characterize occupations, equipment use, and injury and illness incidence rates in greater detail are needed in addition to analyses of actual time worked at different hazardous tasks.

Workers, engineers, or other interested parties (referred to here as stakeholders) assess risks by implicitly considering factors such as value, benefit, feasibility, and acceptance. These qualitative perceptions are invaluable for identifying strategies for reducing risk. Therefore, stakeholders are an important source of input in selecting interventions to be evaluated in a quantitative risk assessment.

#### **AVAILABLE DATA FOR ADDRESSING MINING INJURY HAZARDS**

The primary source of injury data for the U.S. mining industry is the "Mine Accident, Injury, and Illness Report" that is submitted to the Mine Safety and Health Administration (MSHA). This information is required under Title 30, Part 50, of the Code of Federal Regulations for every mining accident, injury, or illness. Information in these reports includes commodity, location, information on the injured person, job title, source and nature of the injury, machinery involved, and severity of an injury. Severity of injury is based on whether a fatality, a disabling injury, or lost days occurred. A complimentary report, "The Quarterly Mine Employment and Coal Production Report," is a source of data on mine location and worker employment corresponding to those mines reporting accidents, injuries or illnesses. Information from each of these sources is compiled by MSHA into accident-injury-illness and address-employment files for both operators and contractors. Data from the address-employment files provide employment totals to the level defined by commodity class and location, such as underground nonmetal or surface coal.

Errors in the MSHA accident and employment files arise because of misclassification of information submitted. Such errors need to be considered in any analysis of these data. Other, more significant limitations on the use of MSHA data in risk analysis are that information on causes is insufficiently described and that detailed exposure data are not available. Only the imme-

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diate circumstances associated with an incident are listed, and no reference is given to preceding events or contributing factors. Exposure data are only available by location and not for specific tasks or even for job title or type of machinery used. As mentioned previously, more detailed exposure data are necessary to evaluate the potential for risk reduction from interventions.

Ongoing research is addressing shortcomings in the usefulness of MSHA injury data for risk assessment. An injury database used in Australia that includes events and conditions that precede injuries is being evaluated at the Spokane Research Laboratory (Feyer and Williamson, 1997). The Pittsburgh Research Laboratory is designing a population survey similar to one conducted in 1986 by the former U.S. Bureau of Mines (Butani and Bartholomew, 1988) to obtain the demographic data necessary for conducting a detailed analysis of injury incidence rates.

### RISK REDUCTION

Risk assessments do not sufficiently emphasize the impact of research interventions on health and safety risks. The process described here begins by developing prospective interventions using injury data, stakeholder input, or the results of task analyses or time studies. Task analysis is a process of describing interactions among workers and machinery or other work systems. Task analyses can be used to identify potential hazards, estimate exposure to specific hazards, and develop interventions. Time studies are conducted by timing the duration of different work tasks. The results of time studies can be used to estimate exposure to specific hazards and to evaluate the impact of proposed interventions.

The overall effect of an intervention on population risk can be characterized by the population incidence rate, the fraction of the population exposed, an average of the proportion of time exposed to the hazard addressed by the intervention, and the effectiveness of the intervention at abating the hazard. An intervention may also reduce risk by reducing the severity of an injury because risk is a function of both the probability of occurrence and severity. Therefore, the degree of reduction in risk to be expected from an intervention can be calculated as the product of the population incidence rate, the fraction of the mining population affected by the intervention, the expected degree of success of the intervention, and the expected change in the severity of injuries resulting from the intervention.

### EXAMPLES AND DATA NEEDS

Three examples of current health and safety problems and possible interventions are described to demonstrate the difficulties encountered when evaluating the degree of risk reduction expected for a range of research alternatives. The example problems and interventions are (1) reducing strains and sprains to rock drillers by reducing the weight of jackleg drills, (2) reducing noise-induced hearing loss in rock drillers by modifying jumbo drills,

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and (3) reducing fatalities in open-pit mines by improving methods for designing slopes to prevent slope failures.

**Jackleg Drillers**

The jackleg drill is a portable, air-operated drill used in underground hard-rock mines. It weighs approximately 100 pounds. Back sprains or strains to jackleg operators account for 30% of the reported injuries to rock drillers that resulted in time lost from work. Reducing the weight of the jackleg drill by as much as 50 pounds could reduce the number of back injuries and possibly the amount of time lost because of back injuries (McKibbin, 1998, personal communication). One means of reducing weight is to use lighter weight materials. However, reducing the weight of a jackleg drill might result in an increase in vibration and lead to other injuries. One hypothesis is that most back injuries to jackleg drillers occur while the miner is moving the drill. Information relating injuries to specific tasks is needed to assess this hazard in more detail, such as the relationship between weight reduction and the incidence of back sprains and strains, the number of employees exposed to this particular lifting hazard, and the amount of time spent at the specific task of moving the drill or drilling. Occupational survey data or a task analysis are needed as well as a calculation of the relationship among weight reduction, back injury incidence, and days lost per incident.

**Jumbo Drillers**

Modifications to another type of drill, the jumbo drill, are proposed to reduce noise-induced hearing loss in rock drillers. The decrease in excess risk of hearing impairment can be predicted for the expected level of noise reduction achieved by the modifications (NIOSH, 1972). The primary difficulty in comparing the degree of risk reduction for jackleg drillers by using lighter weight materials and for jumbo drillers by reducing noise levels is how does one compare the severity of the injury? MSHA uses a conversion of 600 work days lost for partial hearing impairment and 3,000 work days lost for total hearing loss for the purpose of comparison to lost-time injuries. This conversion is based on a schedule of time charges established by the American National Standards Institute. To relate 600 work days lost for partial hearing loss to a jumbo driller to actual work days lost by a jackleg driller relies on value judgments. The objectivity of the risk assessment is reduced as a result. As in the first case, the number of jumbo drill operators and the duration of time spent at specific tasks are needed to calculate risk reduction. A task analysis or a time study is needed along with noise surveys to develop interventions that address specific activities where exposure is greatest.

**Slope Failure**

Injuries associated with slope failures are relatively rare. However, when they occur, they often result in fatalities. Probabilistic modeling methods can improve slope design and reduce unanticipated failures by estimating the

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probability of slope failure and then the reduction in risk of failure resulting from a design change. A reduction in the risk of slope failure can be used to estimate the expected reduction in the probability of a fatal injury. For comparative purposes, MSHA assigns 6,000 days lost to a fatality. As in the previous two cases, detailed information on the number of employees exposed and the amount of time spent in specific tasks are the primary missing components needed to evaluate risk reduction.

## DISCUSSION AND CONCLUSIONS

Data available from MSHA can be analyzed to identify when and where injuries happen and, in a general sense, the relative risk to different populations. This is a necessary starting point; however, often the best opportunities to reduce risks are not revealed by analyses of injury statistics. The MSHA data do not address the causes of or circumstances leading to injuries, nor do they provide an assessment of risks related to specific event sequences preceding injuries. Most importantly, the potential for successful intervention strategies is ignored.

A full consideration of risk is necessary to determine the potential for reducing risk. Such a consideration requires detailed information on exposure to specific hazards and consideration of how injury severities are compared. The nature of injury hazards is diverse, and no single method can measure absolute risk objectively. Value judgments are always necessary. Consequently, the emphasis in risk assessment of mining injuries should be on incremental improvements in risk reduction by research interventions.

A risk reduction framework also facilitates objective measurement of research results as mandated by GPRA. Measurement of absolute reductions in injury incidence is rarely possible. However, criteria based on intervention design measures can be related to risk reduction. For example, design measures in the three examples could be weight reduction achieved for the jackleg drill, noise reduction achieved for the jumbo drill, and reduction of uncertainty in slope design. Relative impacts can be estimated based on risk reduction.

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