SURVEILLANCE OF DISASTER--A VIEW FROM THE DENOMINATOR

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Introduction

The National Institute of Occupational Safety and Health (NIOSH) is dedicated to achieving "safety and health at work for all people -- through research and prevention." An important procedure in pursuing this goal is the NIOSH surveillance studies where the number of injuries are monitored according to demographic, employment, and injury characteristics. These numeric data are then used to identify injury risk factors, develop safety programs, and monitor implemented remediation methods. In essence, ongoing surveillance data form the bases for directing the resources of NIOSH in setting of research and prevention priorities, and in evaluating safety procedures.

This surveillance technique, which is based on the Public Health Service approach to identification and control of disease (1, 2), has been used quite successfully in dealing with relatively high number injuries such as hearing loss, musculoskeletal disorder, respiratory disorder, falls, etc. (3). However a problem arises when extending this paradigm to lower frequency traumatic events; particularly those often referred to as disasters (i.e., high impact events like mine explosions, airplane crashes, etc.). One can ask the question - there hasn't been a coal mine fire fatality in the U.S. for over ten years, to what extent should we be concerned with mine fire safety (resource-wise)? - The National Traumatic Occupational Fatalities (NTOF) system (4) which NIOSH uses to survey occupational fatalities annually, would suggest that underground mine fires would not be a high priority item in occupational safety. Yet, miners' (i.e., the exposed workers) do consider mine fires and explosions to be major safety concerns.

I believe that we need to rethink our evaluation of work place disasters, what is worker exposure, and what are the underlying assumptions (both explicit and implicit) as to the impact that economic, societal and degree of hazard factors make on risk evaluation. The answers to all these problems, will require much broader considerations than those in current surveillance safety and health models. This paper discusses some facets of those considerations.

Surveillance and Hazard Factors

The problems referred to above can be elaborated on in terms of the 'numerator' and the 'denominator' of surveillance information, which generally involves a count of the injured or killed (in the numerator) as normalized to some time interval and number of exposed workers (in the denominator). For example, the NTOF surveillance system (4) evaluates the annual rates of fatalities per 100,000 workers for given standardized categories (e.g., type of industry, cause of death, and other demographics). Similar surveillance data for non-fatal injuries are classified by the U.S. Bureau of Labor Statistics (BLS) for all industries (5) and by the Mine Safety & Health Administration (MSHA) for mining (6)[1]. The NTOF rates are often used for ranking the more hazardous industries and occupations, and for justifying specific research programs.

Aside from the tacit assumption that every worker is exposed to every cause of injury, the rankings of the NTOF risk factors assumes that risk based on fatality would correlate with the non-fatal risk factors -- an assumption that is apparently not always correct. This can be seen in figure 1 which depicts the relative ranking of risk for fatal and non-fatal injuries in 1993 for 11 industry classifications. Here, the relative rankings of the different industries are normalized to the highest value of risk in each category (i.e., fatal and non-fatal). It is readily seen that the fatal and non-fatal risk factors do not necessarily correlate. Of particular note is 'manufacturing', which ranks second in non-fatal injuries, but only fifth in fatal injuries, and 'mining', which is first in fatality risk but only fifth in injury risk.

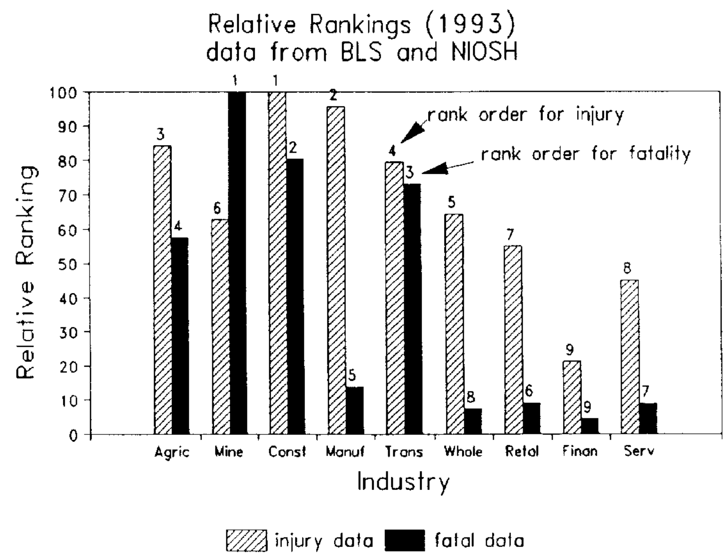

Figure 1. Relative ranking of risk factors for injury and fatality (1993).

This suggests that some degree of hazard factor should be considered when ranking occupational injuries by industry. For example, these same data can be replotted as percent of injury leading to fatality, which might be interpreted as a degree of hazard (figure 2). Here, the 'agriculture' and 'mining' industries have almost an order of magnitude higher degree of hazard than the average for all industries - with manufacturing being among the least hazardous (about one-half the average).

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[1]The industrial classification 'mining' in the NTOF and BLS surveillance systems differs from that in the MSHA system in that the former combine gas and oil industries with mining.

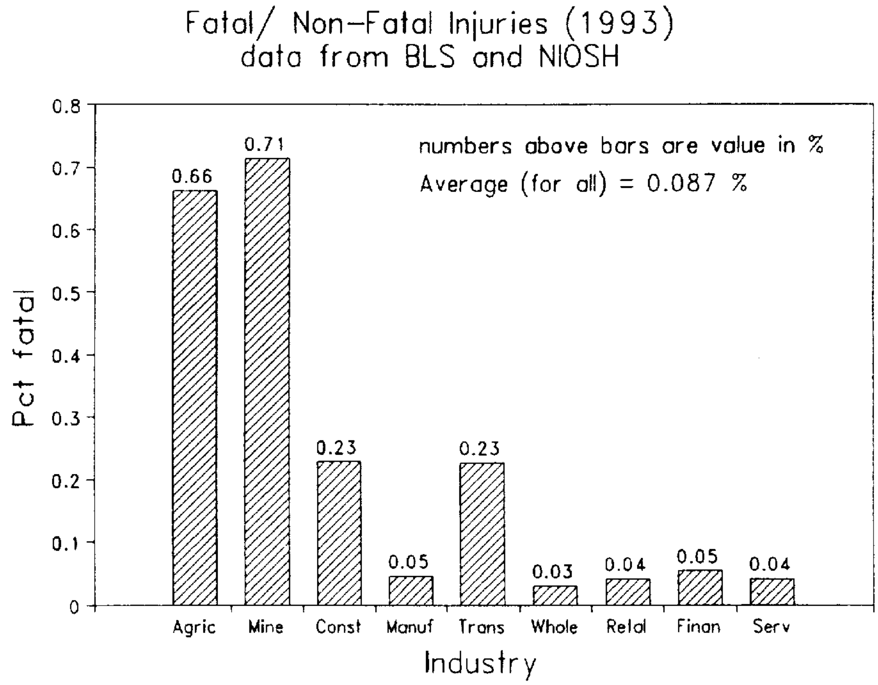

Figure 2. Percent of traumatic injuries that are fatal.

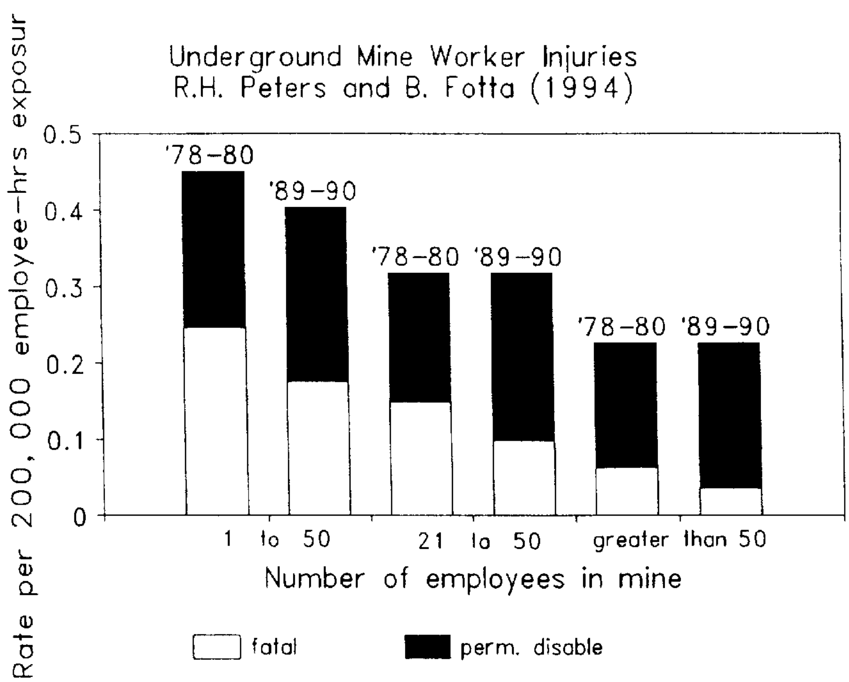

Figure 3. Risk factors related to time period and size of coal mine.

In another surveillance study, this time by the U.S. Bureau of Mines utilizing MSHA data (7), it was reported that the annual rates for coal mining, expressed as fatalities per 200,000 employee-hours of exposure (determined over a three year period) decreased with both increasing mine size and time over the decade of 1980 and 1990 (figure 3). However, the sum of fatal and permanent disability injuries apparently did not change over the decade period. This suggests that the number of events causing traumatic injury might not have changed over ten years, but the types of injury did (e.g., swapping disabling incidents for fatal incidents). In other words, mining was made less hazardous over the ten year period, but not necessarily safer in terms of frequency of injury events. When all the incidents of death, permanent injury and serious injury as reported in reference 7 are considered, the relative risk of injury actually appears to be independent of mine size (figure 4), however, the degrees of hazard apparently do change.

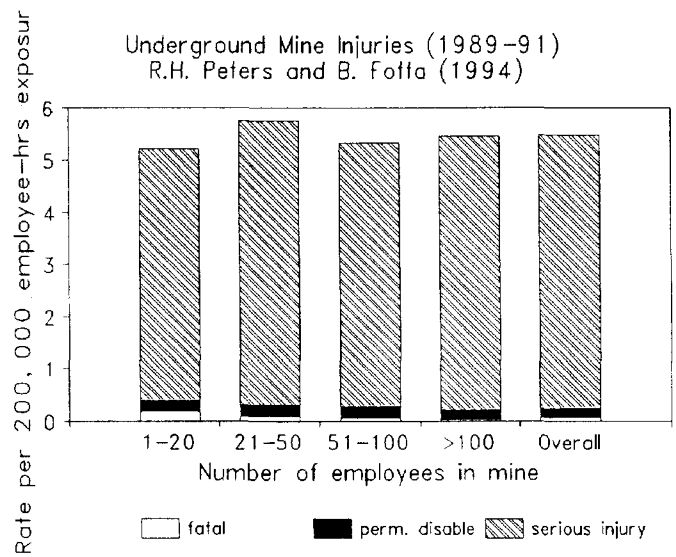

Figure 4. Risk factors for injury in coal mines of various size (1994).

To reconcile the various factors that relate to risk of injury, it is necessary to be concerned (at least in part) with the degree of safety of the work place itself as well as the safety of the work place/worker interface. Namely, that there are a number of events which can occur in the work place, any one of which could lead to worker injury, but only under the "wrong" circumstance. The "wrong" circumstance would occur when there is a worker present at the time of the event. If present during the event, one should then consider what is the chance that he/she would be injured, and to what extent.

A roof-fall in a mine is certainly an event that can cause death and injury to workers, but only when miners are under the roof at the time of the event. The extent of injury to a miner then depends on what part of his/her body was under the roof when it falls. That is, the number of reported injuries by itself does not necessarily define the number of incidents that can lead to injury nor does it define the hazards of the work place. This is somewhat akin to the oft-asked question: "a tree falls in the forest, does it make noise if no one is there to hear it fall?" The answer depends upon our objective -- do we wish to know the rate at which trees are falling, or do we wish to know how many falling trees are heard.

Extending this question to the assessment of roof-fall injuries in a mine, one should consider a number of factors. For example, when and where in the mine and at what frequency do we have roof falls. How many workers are going to be subjected to the roof-fall (not every miner may be exposed to the event), and finally what is the probability that an exposed worker will be injured or killed.

Surveillance and Other Factors

The above discussions dealt with quantities that relate to degree of hazard, but there are also economic, and social concerns which impact directly on individual workers, groups of workers, the work place, the industry, and to society in general. For example, with regard to economics, one can refer to the recent NORA document which states -- "1994 occupational injuries alone cost $121 billion in lost wages and productivity, administrative expenses, health care and other costs". -- This economic impact (about $16,000/occupational injury) as well as other impacts (hazards and societal) need to be considered in the assessment of risks, but often it is uncertain as to how to quantify them.

If one interprets the 'numerator' of surveillance rate data as referring to those individuals, institutions and events which are directly affected by work place injuries, then weighting factors that would relate to the numerator (referred to as N-factors) might be described as

Numerator or N-factors

1. Hazard Impact -- the actual number of workers injured and the degree of injury.

2. Economic Impact -- the direct costs of the accident to industry, government, and injured party and family in terms of medical expenses, compensations, entitlements, worker replacement, and business loss.

3. Societal Impact -- the direct impact of the accident to the injured party, his/her family, and fellow employees in terms of anguish, grief, social concerns, mental and physical health,

The 'denominator' of surveillance data can then be interpreted as referring to those individuals, institutions and events which are in harms way, i.e., those who will be affected by future accidents. The denominator weighting factors (D-factors) may or may not cancel out the N-factors during normalization of the surveillance data. However, the reliability of the normalized surveillance data will depend equally on the reliability of the data making up both the N- and D-factors.

Denominator or D-factors

1. Hazard Impact -- the actual number of workers exposed to a specific traumatic injury (e.g., an underground mine explosion may expose all underground workers to fatal injury, but not those personnel who work above ground), the probability of worker injury or fatality, and the frequency of mishaps that might cause injury.

2. Economic Impact -- the cost to workers, industry and the government for improvements in safety and worker protection. For example, increased liability insurance, medical premiums, and health and safety expenditures, worker job loss and financial business loss in the event of industry closure[2].

3. Societal Impact -- the impact of the event on the public, government agencies, workers and industry. Public attention to traumatic injuries (e.g., news media coverage) can lead to significant social consequences, such as alteration of work procedures and techniques, new safety regulations, and changes in safety and health research priorities and funding. This has been delineated by J. M. Bronstein (8) in a discussion of the role of societal impact in the formulation of worker safety regulations as related to the health hazards of dust in coal mines and cotton mills.

The congressional legislation to create the U.S. Bureau of mines in 1910 and to enact the Coal Mine Health and Safety Act of 1969, was a societal response to major mine disasters involving mine gas/dust explosions. The Occupational Safety and Health Act of 1970 forming OSHA and NIOSH was due to growing concerns for the safety of all workers in the U.S.

Evaluating Societal Impact

One method of evaluating societal impact would be to poll the various segments of our society as to their thoughts on a given question (e.g., TV ratings). Another method might be to examine what the newspapers say about the question (e.g., political ratings). If we assume that the news media coverage is a reasonable surrogate for public opinion which in turn will lead to societal impact, then societal impact of industrial accidents might be evaluated through the attention that newspapers give to each accident. Almost all newspapers currently maintain electronic files which can be searched rapidly, and using information retrieval services, news articles can be readily recovered.

The author undertook this approach for coal mine fatalities in the year 1992. This year was late enough to be within the full electronic data coverage, and a coal mine disaster did occur in 1992. A database program called DIALOG (9) was utilized since it was readily available. In proceeding with the test, MSHA supplied a list of coal mine fatalities for 1992, which included coded information on about 38 data categories, describing the fatal event. The victims' name along with 'MINE ACCIDENT' served as the primary key words for the search.

There were 8 categories of 'cause of fatality' listed for 1992, involving 35 separate fatal incidents and a total of 46 fatalities. All except 3 of the incidents resulted in single fatalities. The news coverage data are depicted as bar graphs in figures 5 and 6. In terms of the relationship between cause of death and news coverage, it is clear that 'EXPLOSION' results in far greater news coverage than all of the other cause of death categories combined -- about a factor of ten greater than 'FALL OF ROOF', even though almost the same number of fatalities occurred in both categories. Figure 6 depicts the societal impact of multiple

[2]The 1990 Mathies underground coal mine fire (near Pittsburgh, PA), resulted in no injuries or fatalities, but did lead to about $100 million loss in equipment and property (an N-factor), and the loss of 410 jobs when the mine was sealed and closed down (a D-factor).

fatality accidents. The words per fatality increase roughly exponentially with fatalities per incident. About 91% of the fatal incidents in 1992 involved single fatalities, accounting for 70% of all the fatalities. Yet their societal impact in terms of news coverage accounted for only 7% of the words published. This is probably similar to the societal impact of automobile crash fatalities as versus airplane crash fatalities.

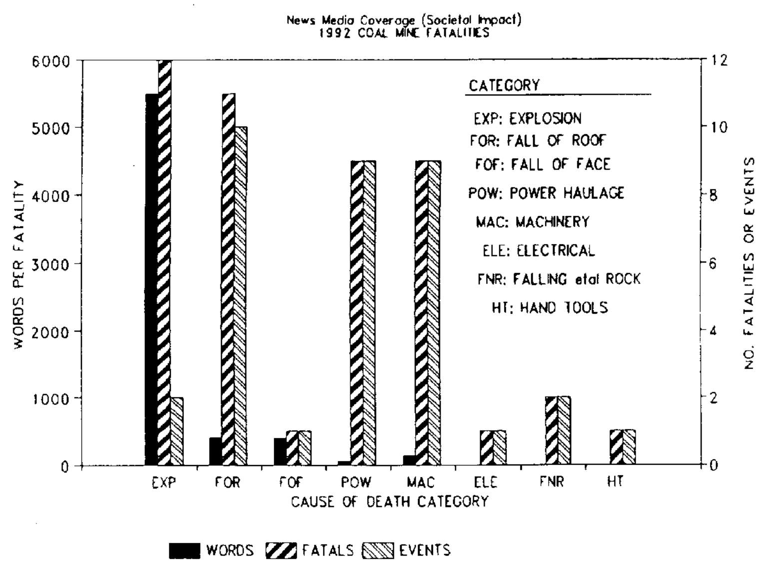

Figure 5. News media coverage of underground coal mine fatalities (1992).

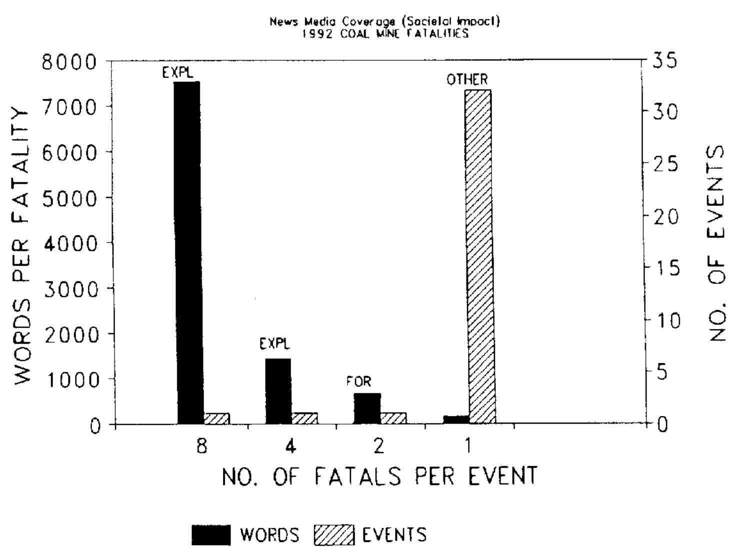

Figure 6. News media coverage as a function of fatalities per event.

Somewhat akin to the above findings is the data reported by Frost, Frank and Maibach (10) which indicates that news media coverage does not correlate with risk of dying (mortality). Using an approach similar to that described above, but with different news publications and methods of measurement, national news media coverage was characterized for 11 different categories of cause of death for the year 1990 - ranging from heart disease and malignancy to trauma such as homicide and unintentional (figure 7). Homicide, with a lowest mortality as a cause of death, was found to be of greatest concern to the exposed American public (a D-factor) -- greater than heart attack (highest mortality), by about a factor of 20. The results indicate that there is less news coverage in the case of causes of death which most people eventually die of, i.e., when you get old (malignancy may be an exception). On the other hand, news media coverage appears to be greatest for those causes of death which involve a younger exposed population, i.e., those at an age not normally expected to die. A ranking of mortality risk taking into account age or lifetime lost (e.g., reference 11) might result in a closer correlation between news media coverage and risk of dying.

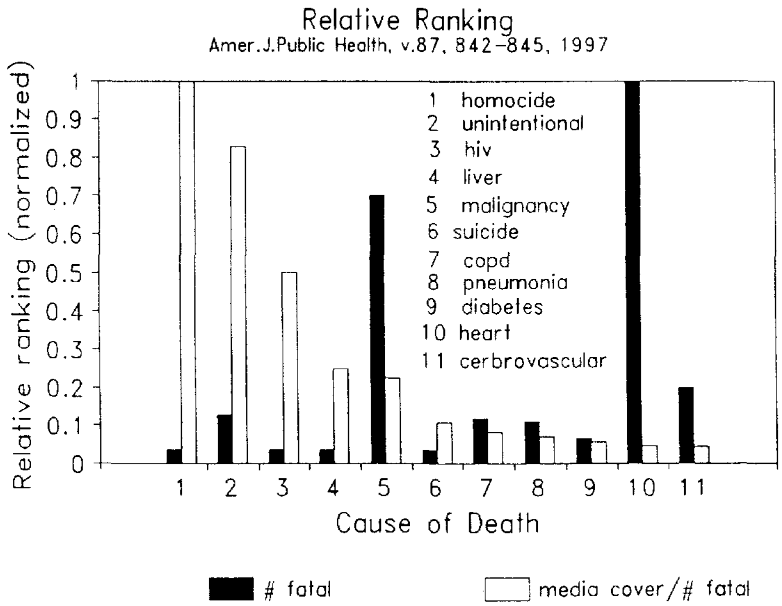

Figure 7. Relative rankings of causes of death by fatalities and by news media coverage.

Summary

The NIOSH surveillance model of risk assessment tends to be concerned with evaluating in great detail the number of people killed (the numerator part of the fatality rate), while the evaluation of those factors which refer to the people exposed (the denominator of the fatality rate) are given much less attention. Yet, the numeric values assigned to the numerator and denominator contribute equally to the value of a risk factor.

The N- and D-factors of risk are much more involved than simply the numbers of injured or exposed. They involve economic, degree of hazard and societal impacts that should be considered in evaluating risk - particularly for low frequency disaster-type events. These additional factors will relate differently to the numerator and denominator of risk and hence can easily effect risk evaluations. This is particularly important in the case of disasters where the evaluation of D-factors requires far greater attention than what is currently being given in current risk analysis models. The importance of the D-factors becomes even more apparent when it is realized that the exposed workers are the ones in harms way, and it is their health and safety that needs to be protected.

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