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A COST-BENEFIT ANALYSIS OF VARIOUS COMPANY  
OCCUPATIONAL SAFETY ACTIVITIES

by

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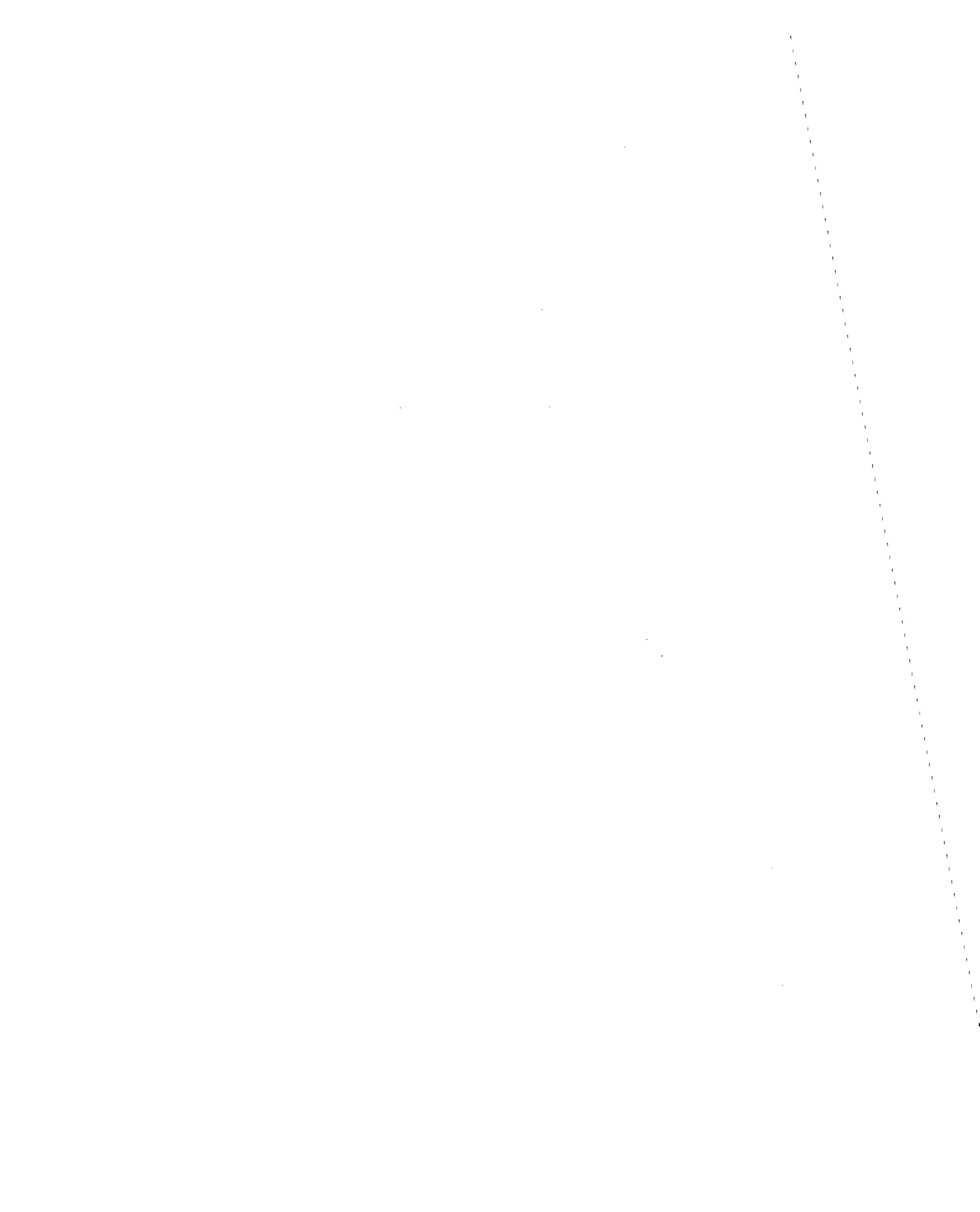


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## ABSTRACT

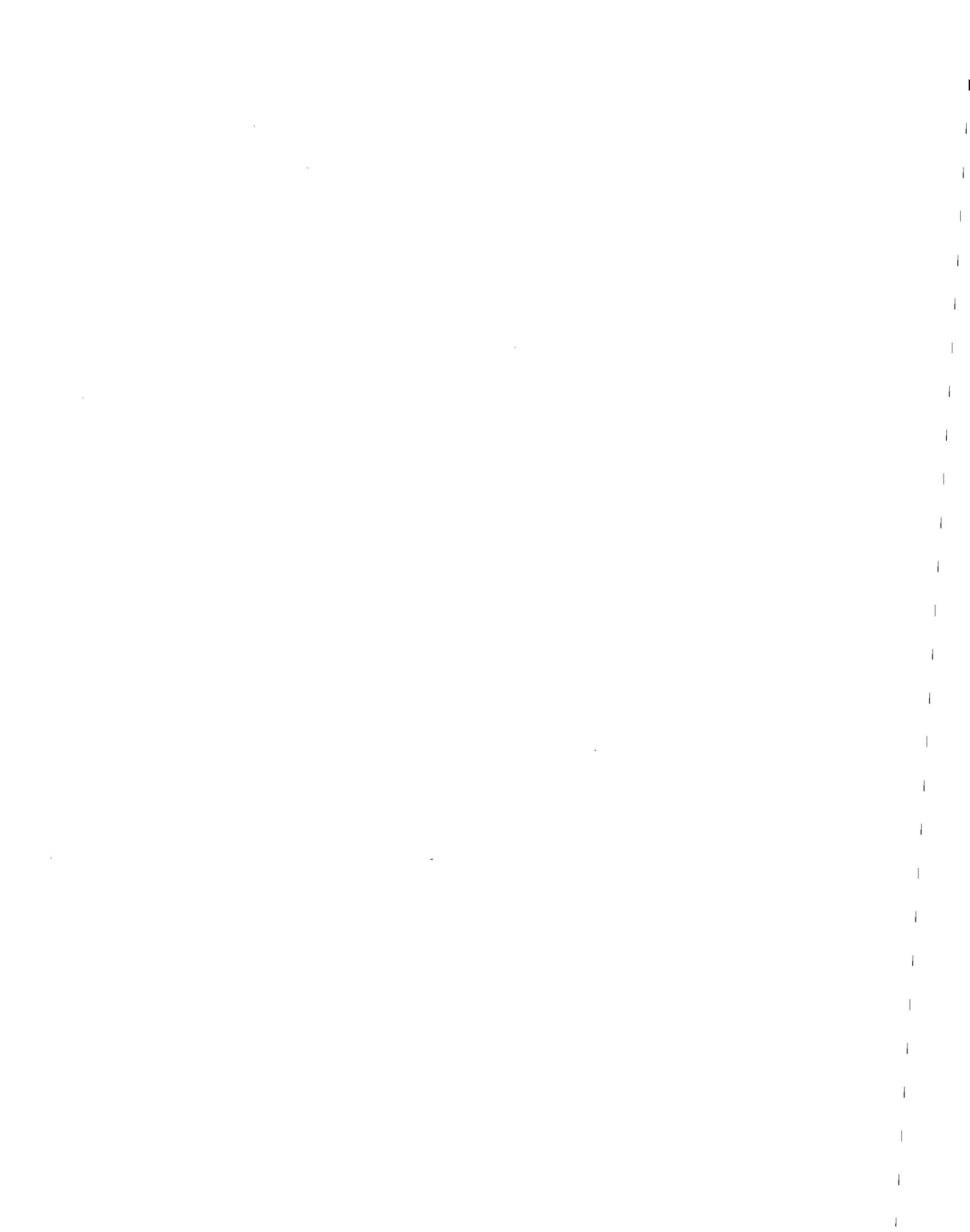
The primary purpose of this research was to estimate relationships between the monetary cost of occupational safety and health loss control activities and the monetary cost of work injuries. A second purpose was to estimate relationships between expenditures for the following variables and the monetary cost of work injuries: top management participation, safety and health staff, new employee orientation, safety rules, activities to maintain interest, safety meetings, safety inspections, personal protective equipment, guarding or the correction of unsafe physical conditions, physical examinations, medical supplies and staff, off-the-job safety activities, safety training, safety records and supervision of span of control.

In order to test hypotheses about these relationships information was obtained from Texas chemical, paper and wood product manufacturing firms by means of 54 on-site interviews and 86 responses to a mailed survey instrument.

Qualitative evaluations generally indicated a strong correlation between top management interest and the work injury frequency rate. By means of a forced-choice procedure, respondents judged the following variables to most effectively reduce work injuries: top management interest, new employee orientation, guarding, safety meetings and safety inspections.

Quantitative measures of the effect of these various safety and health loss control activities upon the monetary cost of work injuries to firms indicated:

- Texas chemical firms spent more money to prevent work injuries and experienced relatively low work injury costs. These costs were approximately equal for Texas paper product manufacturers. Texas wood product respondents spent less on safety activities and experienced higher injury costs.
- A correct combination of safety and health loss control activities rather than greater monetary expenditures explained differences between work injury costs for firms of similar size in the same industry. In fact, firms with lower work injury costs usually spent somewhat less on loss control activities than firms with higher work injury costs.



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## CHAPTER I

### INTRODUCTION

#### The Nature of the Problem To Be Examined

Significantly greater awareness of the magnitude and seriousness of occupational injuries and diseases has occurred in the United States in recent years for a number of reasons. Some of these reasons are increased public attention to the quality of life, the passage of the Federal Occupational Safety and Health Act in 1970, greater publicity given to work injuries and occupational diseases (particularly multiple fatality incidents and chemical induced occupational diseases), the activities of various consumer groups and the activities of organized labor. This increased awareness, interest and activity has occurred among four general groupings of the population. It has occurred among members of the general public primarily for the reasons stated. Second, greater activity has occurred on the part of state and federal agencies as government has reflected these concerns through legislation and its enforcement. Third, many employers have devoted more time and expended more money on occupational safety and health, both because they consider it good business and the right thing to do and in order to comply with requirements of the Occupational Safety and Health Act. And finally, in recent years employees of many organizations have expressed greater concerns as they have become more aware of potential problems and have realized that there are some alternatives available to them.

One of the results of the increased awareness of and interest in occupational safety and health has been some increase in research directed toward understanding causes of work injuries and occupational illnesses. Much of this research has been funded by the Federal National Institute for Occupational Safety and Health. Generally this research has focused upon the determination of appropriate means to reduce occupational diseases, the establishment of appropriate curriculum and career paths for the training and development of occupational safety and health specialists and upon the determination of the causes of work injuries. Less research has been done to try to determine economic aspects of safety.

The importance of this economic relationship between work injuries and occupational safety and health loss control activities was understood by The Honorable Phillip Burton, Representative from California, when he appended a separate and concurring view to the majority report recommending the passage of H.R. 16785, which, with modifications, became the Occupational Safety and Health Act of 1970. Representative Burton's comments are lengthy but deserve a full review in this text. They are:

This bill represents a long-overdue significant additional recognition that working men and women need Federal assistance to secure their

inalienable right to earn their living free from the ravages of job-caused death, disease and injury. This bill is also a testimonial to this Committee's faith that the formalization of standards and standard setting, coupled with enforcement, will bring a reduction in the high level of death, disease, and injury.

While I share the conviction that standard-setting and enforcement is an appropriate Federal responsibility, I am gravely concerned that this bill may not go far enough to reach and remove the root causes of the macabre facts of life in the working place. More specifically, I am convinced that most of the diseases and a substantial portion of deaths and injuries are not the result of worker carelessness, but are avoidable by management's exercise of preventative measures. Unfortunately, the costs of the necessary preventative measures appear, even in 1970, to exceed the costs to employers from the employee injuries which may occur without these expenditures. Therefore, until and unless the basic economics of these disasters are changed, nothing in the working place may change. Thus, with today's low level of Workmen's Compensation, preventative expenditures for better health and safety are often the employer's most expensive and uneconomic choice. In short, today's Workmen's Compensation laws and associated laws offer an economic incentive to many corporations to forbear from preventative expenditures because they have concluded that the costs of employee death and injury (potentially higher Workmen's Compensation, Health Insurance premiums, etc.) are often less than the costs of accident and disease prevention.

I believe that employers in every state should be able to invest in better safety and health and know that they are saving money for every death and injury which is prevented. At the very least, I believe that any employers who choose to spend funds for preventative safety and health measures should not be economically penalized for that decision. Employers in states with the higher levels of Workmen's Compensation payments should not be at an economic disadvantage with reference to employers obligated to pay far lower levels. Without this equality, and without a higher value on human life and health from higher Workmen's Compensation standards, an uncertain and unnecessary number of deaths and injuries will be occurring each year.

To achieve the goals of making safety and health economic and effective, the state levels of workmen's compensation should be adequate and relatively uniform. National, uniform, minimum standards of benefits, universal coverage, and comprehensive medical and related benefits appear to be the minimum initial commitment which working men and women should have as a matter of right. More specifically, any levels of workmen's compensation should be sufficient to adequately sustain a widowed spouse or family otherwise incapable of support. The actual level of many State Workmen's Compensation payment programs portrays an obviously inadequate program both in terms of benefits and coverage. However, this portrayal is only the vague outline of the hundreds of thousands of cases of uncompensated loss to working men and women each year. Such losses are staggering in amount--

both in their aggregate size and in their actual impact on workers' families. Such losses are particularly harsh when they fall on the majority of men and women who work without the benefit of a union and an adequate compensatory health plan. Such losses are unconscionable when they are the result of negligence by the employer for which the worker has no legal remedy in court.

I believe this bill must rapidly eliminate the source of these wrongs in the workplace by significantly lowering the incidence of death, disease, and injury. I will be reviewing the record of this progress carefully. If such a decrease in death, disease and injury does not rather rapidly take place and continue, and if the character of other rights of working men and women is not raised to a humane level by the states, then I believe this committee must adopt the additional, alternative, and more basic economic solutions I have suggested above.\*

Essentially, these comments suggest that most employers will consciously or unconsciously pursue a course of action in regard to occupational injuries and illnesses which will best benefit them. This statement further suggests that if the standard setting and enforcement procedure does not produce results which are as great as desired, attention should be directed toward an economic solution to this problem. As suggested by Representative Burton, an economic solution could be provided by raising workmen's compensation benefits. Another way in which such a solution or progress toward further reductions in the economic costs of work injuries could occur would be if there were further understanding of the cost to organizations of work injuries and illnesses. This is an important question to which little research has been directed. The author believes that such reductions in the number and costs of injuries can most effectively occur at this time by the leadership, appropriate actions and attitudes of responsible individuals in organizations rather than by the actions of governmental agencies, by the actions of individual employees or by the actions of safety meetings, safety inspections, personal protective equipment, correction of unsafe physical conditions, medical staff and supplies, off-the-job safety, safety training, and safety records.

#### Importance of the Study

Useful additional information about ways that the number and cost of work injuries can be reduced would be of interest to many individuals and to responsible parties in a number of different types of organizations in the United States. First, such information should be of interest to the managers and to safety and health specialists in various organizations as they try to more effectively and efficiently reduce and prevent such incidents. Second, such information should be of interest to Federal, State and local government officials who have the responsibility of administering the requirements of existing occupational safety and health legislation and to those who establish public policy. Third, such information should be of importance to individual workers and employees who should have the greatest interest in answers to questions about how work injuries and illnesses can be reduced.

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\* U.S. Congress, House Committee on Education and Labor Hearings on the Occupational Safety and Health Act of 1970, H.R. 16785 (Washington, D.C.: Government Printing Office, 1970), Ref. (82).

## CHAPTER II

### RELATED RESEARCH AND INFORMATION

#### Introduction

The purpose of this chapter is to provide some background information about the measurement of the safety performance of organizations. Information about the measurement of the number and cost of work injuries in business organizations in the United States will be presented first. Data about the measurement of the incidence and seriousness of occupational diseases in the United States will be provided next. Then some general information about other more recently devised techniques for measuring safety performance will be briefly described. Next, some general information about cost-benefit studies is provided with emphasis on those which measure life safety. Finally, information about studies directly related to this study is presented in some detail.

#### The Measurement of Employee Work Injuries

The Bureau of Labor Statistics, Department of Labor, first made a study of work injuries in the iron and steel industry in 1910. It began to maintain records by industry in 1925 and began to follow the American National Standards Institute Standard, Z 16.1 "Method of Recording and Measuring Work Injury Experience" (2) in 1937, estimating national rates based on a sample of 65,000 voluntarily submitted reports.

The National Safety Council began to maintain some records when it was organized in 1915 and since the 1920's has measured the performance of reporting organizations based on the ANSI Standard, Z 16.1. This system measures the rate at which lost time injuries occur defining this rate as the number of injuries in which the injured is not able to return to a regularly established job on the next regularly scheduled shift per one million manhours worked. The Standard also measures the severity of work injuries in terms of rate which is the number of days lost or in the case of a permanent partial, total disability or death is a scheduled charge in days, again per one million manhours worked.

In 1969 a Bureau of Labor Statistics study group formed by Labor Secretary James Hodgson concluded that the ANSI Standard, Z 16.1, was too complex to be generally useful and too insensitive to accurately measure trends. A 1970 report funded by the Department of Labor and entitled Evaluation of the National Industrial Safety Statistics Program (36), prepared by Jerome B. Gordon surveyed 63 California firms and concluded that the generally accepted National Safety Council figures prepared annually understated the number of work injuries occurring in the United States by ten times. As a result of these reports and of the passage of the Occupational Safety and Health Act of 1970, a second means of calculating the number and seriousness of work injuries has been devised. It is the method used by the Bureau of Labor Statistics, U.S.

Department of Labor which beginning in 1972, measures the incidence rates of the fatal cases, lost workday cases, lost workdays and nonfatal cases without lost workdays for U.S. industry in total and by major sectors (85).

A further and probably relatively common way to measure employee work injuries is to determine the insured cost of work injuries. This can be the cost of workmen's compensation insurance or the monies paid as a result of work injuries and to hospitals and physicians for medical care and services plus an estimate of insurance company services.

Relationships between costs of work injuries were first formally measured by H. W. Heinrich. In a pioneering study and book entitled Industrial Accident Prevention (38) published in 1931 Heinrich outlined principles of accident prevention, suggested a basic philosophy of accident prevention and described the components of an accident prevention program.

Based upon an extensive analysis of cost information obtained from many firms he hypothesized that there were indirect or hidden or noninsured costs of work injuries which he estimated to be four times the direct costs of work injuries.

These indirect costs, according to Heinrich, consist of the following:

1. Cost of lost time of the injured employee...
2. Cost of time lost by other employees...
3. Cost of time lost by foremen...
4. Cost of time spent by first aid attendants...
5. Costs due to damage to machines, tools or other property...
6. Incidental costs due to interference with production...
7. Costs to employers under employee welfare systems...
8. Costs to employers in continuing the wages to the injured employee...
9. Costs due to loss of profit on the injured employee's productivity...
10. Costs that occur in consequence of...weakened morale due to the accident...,
11. Overhead costs per injured employee...1/

A close look at these indirect or noninsured costs of work injuries was taken by Rollin H. Simonds in a 1949 Ph.D. dissertation research study entitled,

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1/ H. W. Heinrich, Industrial Accident Prevention (New York: McGraw-Hill Book Co., 1931), p. 51-52, Ref. (38).

The Development and Use of a Method for Estimating the Cost to Producers of their Industrial Accidents (69). Simonds indicated in a summary of this study and a broader look at the question<sup>2/</sup> that based upon a study of 1100 both injury producing and non-injury producing accidents the average uninsured cost per case for lost time cases, doctors cases, first aid cases and for non-injury accidents could be computed. This book further indicated that when all of these data are not available "The ratio of 1:1 (indirect noninsured to direct insured costs) found in the Simonds' studies may be used as an approximation..."<sup>3/</sup>

The third approach to understanding the total cost of work accidents was proposed by Frank E. Bird, Jr., and George C. Germain in Damage Control (6) published in 1966. Based upon an analysis of 90,000 accidents which occurred at the Lukens Steel Company in Coatsville, Pennsylvania over a seven year period of time these authors concluded that every disabling injury, 100 minor injuries and 500 property damage accidents happened.

Because of the infrequent occurrence of work injuries in proportion to work activities and to unsafe acts, various means of obtaining information about the more frequent near miss incidents have been proposed. T. H. Rockwell proposed work sampling techniques in 1970 (65). William E. Tarrants in a 1963 doctoral dissertation at New York University entitled An Evaluation of the Critical Incident Techniques as a Method for Identifying Industrial Accident Causal Factors (74) suggested the use of that technique. In 1966 James M. Dashback in a doctoral dissertation done at Oklahoma State University (21) indicated that a study of hazards in the work place made by means of a photographic record concluded that the frequency of accidents is low in comparison to the frequency of safety hazards in a given time period and, therefore, that a measure of safety hazards gives a better means of evaluating safety effectiveness than a measure of work injuries.

Several proposals have been made to improve the sensitivity of standard measures of the rate at which work injuries occur. The American National Standards Institute Standard method, Z 16.1, provides a non-standard measure, the serious injury frequency rate. This index consists of the calculation of a rate for work injuries which result in temporary total disability, permanent disability, transfer to work other than the injured's regular duties, fractures, lacerations requiring sutures and eye injuries requiring a physician's attention. Charles L. Gilmore in an insightful book entitled Accident Prevention and Loss Control (34) published in 1970 indicated that control charts and learning curves can be used to predict future work injury trends.

Summarizing, a considerable amount of work has been done to develop measures of work injuries and most business organizations probably currently utilize one or a combination of these measures to evaluate their own safety performance.

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<sup>2/</sup> R. H. Simonds and J. V. Grimaldi, Safety Management, Third Edition (Homewood, Ill.: Irwin and Co., 1975), Ref. (70).

<sup>3/</sup> Ibid., p. 412.

The National Safety Council provides one measure of work deaths and injuries in the United States. In 1974 the Council estimated that 13,500 work deaths and 2,400,000 disabling injuries occurred. It estimated the insured cost of these incidents to be \$6.8 billion and the indirect noninsured cost \$6.8 billion or a total cost to the nation of \$13.6 billion in 1974 (59).

### The Measurement of Occupational Diseases

Less is known about the number and seriousness of occupational diseases which occur in the United States partly because the occurrence of an occupational disease often involves more subtle physiological changes rather than the more dramatic event of a work injury, partly because many state workmen's compensation laws have until recently rather narrowly defined those occupational diseases which were compensable and partly because occupational diseases appear to occur much less frequently than work injuries.

However, a number of occupational diseases have been known since very early times. Lead poisoning was reported by Hippocrates in 4 B.C., Pliny the Elder reported mercury poisoning in 100 A.D. and Agricola reported on silicosis in 1556. Ramazzini prepared a text on industrial health in 1700 and Orfila wrote about the quantitative analysis of harmful chemicals in 1815.

The passage of state workmen's compensation laws in the United States beginning with several states in 1911 began to stimulate employer interest in occupational diseases. State laws began to specify that certain occupational diseases were compensable because they arose "out of and in the course of employment". In 1946, only 18 states gave full coverage of occupational diseases under their workmen's compensational laws. In 1973, 42 states, five territories and two Federal laws--The Federal Employees' Compensation Act and the Harbor Workers' Compensation Act--provided coverage of all occupational diseases (16). In spite of this broadening of coverages problems remain. The Report of the National Commission on State Workmen's Compensation Laws stated that, "In addition the statute of limitations is so short in some states that many diseases are not compensatable because symptoms appear long after exposure."4/

A number of university dissertations have also addressed themselves to this problem. Raymond Kary at the University of Iowa in 1967 concluded after an analysis of occupational diseases workmen's compensation claims that the Iowa incidence was similar to national averages (43). James Anderson at the University of Colorado concluded in 1967 that Federal legislation is needed to properly protect and compensate workers exposed to ionizing radiation (3). Of more general interest, after reviewing all state laws, in 1956 William Thuss at the University of Cincinnati determined that occupational disease laws by definition not schedule should be added to state statutes when this had not been done (77).

State occupational health regulations may also influence the incidence with which occupational diseases occur. Summaries of these laws were prepared by

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4/ U. S. National Commission on State Workmen's Compensation Laws, The Report of the National Commission on State Workmen's Compensation Laws (Washington, D.C.: Government Printing Office, 1972), p. 48, Ref. (87)

Victoria Trasko of the U. S. Department of Health, Education and Welfare in 1970 (79). A. D. Hosey and L. Ede of the Department of Health, Education and Welfare reviewed all of these state health laws in 1970 (40) and concluded that there was a significant lack of uniformity among these laws, that many standards were not up to date, that many different agencies within most states administered these laws and that only twenty states had established occupational health programs by statute.

Finally, Federal legislation appears to be directing increasing attention and resources to this problem. The Occupational Safety and Health Act of 1970 may be having some effect on the problem of occupational diseases in the United States through such activities as funded research, criteria document preparation, inspections, citations and fines.

Some studies of occupational diseases in communities, counties, standard metropolitan statistical areas or states have been performed in the United States. Flynn and Miller made such a study in 1946 as a part of a Chicago-Cook County health survey (30). C. D. McClure has reported on a 1968 occupational health survey of 803 randomly selected plants in Chicago performed by U. S. Public Health Service employees in conjunction with a survey performed by the Institute of Medicine of Chicago (47).

In 1971 Brown, Corn, and Sansone of the Graduate School of Public Health of the University of Pittsburg made a study of representative workplaces in Allegheny County, Pennsylvania and made estimates of the number of occupational disease cases in the county by major industrial grouping (11).

Finally, the University of Washington monitored selected high hazard workplaces in Tacoma, Seattle, Portland, and Yakima County, Washington from July 1972 to August 1974 and gave physical examinations to certain workers in a study headed by Dr. David Discher (88). This study published in 1975 concluded that an incidence rate of occupational disease symptoms of one out of every four workers occurred in this sample.

Currently, two states prepare reports which provide detailed data about occupational diseases. The California Department of Public Health publishes an annual report entitled Occupational Disease in California which lists the rates at which occupational diseases have been reported by major S.I.C. codes and by type of disease. Briefly, this report indicated that in 1968, similar to the experience of other years, occupational diseases represented 4.6% of all reported injuries and diseases in the state (14). The Department of Commerce in Florida also publishes an annual report of workman's compensation cases. It is entitled Cases, Causes and Costs: Analysis of Work Injuries Covered by Workman's Compensation (29). In 1969 this report indicated that the 2,851 reported occupational disease cases represented 4.1% of all compensable injuries and diseases, and accounted for 4.1% of all days lost and 2.2% of the compensable cost of reported injuries and illnesses.

An estimate of the number of occupational disease cases in the United States was given by Dr. Marcus Key during 1968, 1969 and 1970 testimony to the Senate Committee on Labor and Public Welfare during hearings on the then proposed Occupational Safety and Health Act. At that time Dr. Key indicated that an estimated 390,000 occupational disease cases occur each year (83).

The President's Report on Occupational Safety and Health, 1971 (85) indicates that occupational illnesses were seldom reported under the Z 16.1 measure and that "...lack of uniformity of State laws preclude a realistic counting of illnesses befalling workers on the job..."<sup>5/</sup> which should be resolved by the OSH Act system of reporting. The 1972 President's report (86) indicated that occupational illnesses or diseases accounted for a relatively small percentage of recordable injuries and illnesses reported during the last 6 months of 1971 to the USDL but that this "...may not reflect all occupational illnesses since...some may not have been recognized as such..."<sup>6/</sup> 464,000 illnesses or 4.3% of all injury and illnesses cases requiring medical attention or involving a loss of time were reported. Projected to an annual basis this would be 928,000 cases per year.

In summary, while significantly fewer occupational disease cases and costs in relation to work injuries are reported there is an increasing awareness of the nature and potential of such incidents in the United States at this time.

#### Newer Measures of Employee Work Injuries

Several newer techniques are available and are used by a number of business organizations to measure and predict the safety performance of organizations and to help reduce work injuries.

Systems safety analysis techniques have been developed to quantitatively measure the probability that various undesired events such as work injuries and deaths will occur in a given situation. One of these techniques is fault tree analysis, devised by the Bell Telephone Laboratories and developed by the Boeing Company in the 1960's. It consists of determining the logical relationship between various events and of computing the probability that undesired events will occur (70). Another technique, the failure mode and effect method, similarly determines logical relationships between various events and probabilities. However, it begins with the failure of a part of the system and determines what the result of this failure would be to the system and the probabilities of such an occurrence. In 1970 Marvin Gates and Amerigo Scarpa suggested that because life safety is always relative, each level of safety requires a different level of investment. The authors then provided a mathematical formula by which such calculations could be made (32).

In 1971 William T. Fine of the Naval Ordnance Laboratory determined a method of calculating whether the estimated cost of correcting an unsafe condition would be justified in terms of the risk which is reduced by doing this (28). He developed a formula which weighs various factors, calculates the risk of a given situation and gives a numerical evaluation to the degree of risk. He

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<sup>5/</sup> U.S. Department of Labor and Department of Health, Education and Welfare, The President's Report on Occupational Safety and Health, 1971 (Washington, D.C.: Government Printing Office, 1972), p. 53, Ref. (85).

<sup>6/</sup> U.S. Department of Labor and Department of Health, Education and Welfare, The President's Report on Occupational Safety and Health, 1972 (Washington, D.C.: Government Printing Office, 1973), p. 5-6, Ref. (86).

also developed a second formula which weighs the estimated cost and effectiveness of any proposed corrective action against this numeric evaluation of risk and which determines whether this action is justified.

Still another technique is value engineering as applied to occupational safety and health. It was described by John P. Gausch of John Gausch Associates in the May 1974 ASSE Journal (33). The technique compares the various benefits of an action as cost, safety, morale and social to the various choices or courses of action available to an organization in order that decision makers may more fully consider the implications of an action and can quantitatively assess the probable outcome of various decisions or choices.

Other variations on these basic ideas have been proposed by S. K. Dietz in 1967 (24), R. L. Browning of Monsanto's Texas City Plant in 1969 (12), J. W. Croach and L. M. Arnett in 1970 (18) and James A. Cannon in 1974 (15).

To summarize, various newer techniques have been developed primarily during and since the 1960's to better quantify, measure and predict the number, seriousness and cost of employee work injuries. In spite of the apparent value of these techniques their frequent use by many sectors of industry remains relatively rare. The aerospace, aircraft and, to a lesser extent, the chemical industry currently utilize these techniques more frequently than other sectors.

#### Cost-Benefit Analysis

One other technique that can be used to measure the safety performance of organizations is cost-benefit analysis. This in some respects can be somewhat less complex than some other techniques, being simply a measurement of the cost of performing a certain action or actions, a measure of the benefits which occur as a result of these actions and normally some calculation of relationships between these two factors. The technique has been used by economists, engineers, scientists and businessmen for a number of years to evaluate these relationships with varying degrees of precision. It was refined, discussed and used to some extent in France and in England in the 19th century. It has been extensively developed and used in the United States and in other countries in the 20th century; and, particularly since 1945, to analyze problems as diverse as irrigation projects, hydroelectric power schemes, roads, railways, inland waterways, urban renewal, recreation facilities, land reclamation, health programs, public works, educational activities, research and development and defense (50).

Based upon a fairly extensive review of the literature it appears as if either cost-benefit or cost-effectiveness analysis, a technique for comparing the cost of various ways to achieve objectives, has been discussed or utilized with regard to safety problems only in recent years. In a computer search of the literature performed by the Lockheed Information Retrieval Service, 78 studies published by the National Technical Information Service from 1968 to mid-1975 were found. The great majority of these, 54, dealt with a cost-benefit analysis of some aspect of the safety of transportation, primarily motor vehicle but also railroads, marine and pedestrians. Twenty of these references pertained to a cost-benefit analysis involving public safety, principally nuclear safety, and one pertained to fire safety. Two of these

studies were directly related to a cost-benefit analysis of occupational safety or health problems. One of these was a cost-benefit study of the development of radiation exposure standards for uranium miners performed by Battelle-Pacific Northwest Laboratories in 1974 for the National Institute for Occupational Safety and Health (19). The other was a study of their merchant marine safety program performed by the United States Coast Guard in 1968 (81).

In addition, some further information or data about cost-benefit analysis is available. In 1970 J. C. Rossman wrote a dissertation entitled An Approach Toward Applying Cost-Benefit Analysis to an Industrial Health Problem in a Developing Country - Coal Mining in Taiwan (66). David B. Brown of Auburn University published a paper in the June 1973 issue of the Journal of Safety Research entitled "Cost/Benefit of Safety Investments Using Fault Tree Analysis" in which he suggested use of the technique and described it (10).

To conclude, a fairly well established and relatively straightforward technique, cost-benefit analysis, is only beginning to be applied to the subject of occupational safety and health at this time.

#### Directly Related Studies and Information

Because of the somewhat diverse nature of the problem studied, a variety of information has been found to be helpful in providing background information about the problem studied.

One series of studies has dealt with some of the behavioral aspects of occupational safety and health. Roderick Forgren wrote a 1965 dissertation at the University of Colorado entitled A Study of Supervisors' and Employees' Beliefs Concerning Non-Safety Benefits Arising from their Participation in Plant Safety Programs (31). He concluded that based on a study of eight plants, participation in a plant safety program by employees in the plant does provide additional non-safety benefits to the plant. C. H. Allen prepared a dissertation in 1965 at U.C.L.A. which was entitled The Effects of Management Attitude in the Prevention and Control of Industrial Accidents (1). The dissertation was based upon information obtained by both questionnaires and structured interviews and it concluded that both management interest and effective management action were very effective ways of reducing work injuries. Hyler Bracey studying at Louisiana State University interviewed more than 250 safety directors in four different industries and concluded in 1969 that a positive attitude on the part of safety directors most closely correlated with lower accident frequency rates than their education, experience or organization position. His dissertation was entitled An Investigation into the Effectiveness of Safety Directors as Influenced by Selected Variables (9).

The last study of this type directly related to this research is a study made in 1974 by Dr. William H. Mobley of the University of South Carolina entitled Managerial Evaluations of Safety Motivation and Behavior Hypotheses (51). This research which was funded by the National Institute for Occupational Safety and Health and which consisted of an analysis of the responses of 67 safety specialists and line managers in 43 glass and ceramics industry plants concluded that behavioral and motivational factors judged by respondents to be more important are (in decreasing order of importance): safety program supported by top management, supervisors set good safety example, accidents

are often the result of unsafe acts not conditions, supervisors have high safety expectations, the organization is seen by employees as safety conscious, the plant has a tradition of safety consciousness and there is immediate safety training for new employees.

A second series of articles and studies dealt more directly with the present subject and discussed aspects of the economic of occupational safety and health. Reporting in the American Journal of Public Health Dorothy Rice and Barbara Cooper in an article entitled "The Economic Value of Human Life" (60) provided estimates (using 1964 dollars) of the present value of lifetime earnings of people by sex, age, race and years of schooling completed. Lifetime earnings of a 40 year old male, with a high school education, or less, varied from \$60,000 to \$120,000. James T. Sykes, a Safety Officer with the U. S. Forest Service, suggested in 1967 that organizations find the costs of their work injuries, compute the costs of accident prevention and calculate a total cost curve consisting of both costs of injuries and of accident prevention at various all injury frequency rates in order to determine the most economical solution to this problem (73). The title of this article is "Find the Break-Even Point for Safety Investments."

Chauncey Starr in a 1967 article in Science entitled "Social Benefits versus Technological Risk" (72) discussed the level of risks accepted by our society. He concluded that the public will accept much higher voluntary risks than involuntary risks, that the statistical risk of death from disease appears to be a psychological yardstick for establishing the level of acceptability of risk, and that acceptance of risk appears to be approximately proportioned to benefits real or imagined. He further concludes that the social acceptability of risk is directly influenced by public awareness of the benefits of an activity.

In 1972 James H. Johnson wrote a thesis at Texas A&M University entitled Applications of Cost-Effectiveness Studies to System Safety Engineering Problems (42). The work applied cost-effectiveness analytic techniques to the failure mode and effect and fault tree procedures.

In 1974 Paul E. Givens wrote a dissertation at the University of Texas - Arlington entitled A Study of the Contributing Factors to Safety Problems in Texas Nursing Homes (35). The study consisted of a factor analysis of the relationships between 27 safety related variables and the workmen's compensation loss ratios of seven Texas nursing homes. It concluded that an evaluation by researchers of administration responsibility and planning, the administration of safety programs and the physical condition of general use areas correlated most highly with the loss ratios which were used as a measure of safety performance.

Writing in the January-February 1975 issue of Search Michael Henderson of the Traffic Accident Research Unit, New South Wales, Australia discussed issues in "The Value of Human Life" (39). He discussed the need for cost-benefit analysis of traffic accidents in broad terms concluding that, "... in the long run, a balance must be sought between wholly economic and wholly humanitarian principles, so that goals may be established which are acceptable to society, to its elected representatives and to the analysts whose task it is to define the extent to which resources are available and allocate them in

the most beneficial fashion."7/

In addition to these articles and studies two other dissertations dealt with portions of this subject. Bruce Boals' 1969 University of Florida dissertation entitled Some Economic Aspects of Workmen's Compensation in Florida (8) devoted one chapter to accident prevention. And Russell Settle's 1974 study at the University of Wisconsin, The Welfare Economics of Occupational Safety and Health Standards (67), applied cost-benefit analysis to the establishment of safety and health standards. He concluded that such standards could be cost-effective.

The third and last series of studies are those which are directly and specifically related to the subject of this study. One is the Ph.D. dissertation by Yaghoub Shafai-Sharai entitled An Inquiry into Factors That Might Explain Differences in Occupational Accident Experience of Similar Sized Firms in the Same Industry (68). The author studied eleven matched pairs of firms in eleven different Michigan industries and concluded that top management interest and better and more numerous safety devices on machinery strongly correlated with lower accident rates. It also concluded that the following correlated with lower accident rates: a lower span of control or fewer employees per supervisor, better accident records keeping systems, company recreational programs, better physical workplace conditions, and an older, more long service labor force which consisted of more married employees.

The second of these is Alan Diehl's 1974 dissertation at North Carolina State University (23). In this study entitled A Systems Dynamics Simulation Model of the Occupational Safety and Health Phenomenon, Diehl created models of both the accident and occupational disease phenomenon and applied them to three problems in a hypothetical furniture manufacturing firm. The problems he dealt with were different overtime policies, three improvements in the safety program and various levels of production.

The third of these is the June 1975 study by Alexander Cohen, Michael Smith and Harvey Cohen entitled Safety Program Practices in High versus Low Accident Rate Companies - An Interim Report (17). This study was based upon mailed survey data supplied by 42 pairs of Wisconsin companies in the food and kindred products, wood products, paper products, primary metals, fabricated metals and machinery manufacturing industries. Some tentative conclusions of this interim study were that the following tend to lead to improve safety performance: (1) greater staff stature and commitment to safety, (2) greater utilization of outside influences, (3) a greater variety of safety incentives, (4) more job safety training, (5) a more humanistic approach to the disciplining of risk takers, (6) a more stable work force and (7) a safety program which "emphasizes better balance between the engineering and non-engineering approaches toward accident prevention."8/

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7/ Michael Henderson, "The Value of Human Life," Search, 6 (January-February 1975), p. 38, Ref. (39)

8/ A. Cohen, M. Smith, and H. H. Cohen, Safety Program Practices in High Versus Low Accident Rate Companies - An Interim Report (Cincinnati: U.S. Department of Health, Education and Welfare, 1975), p. 68, Ref. (17)

## Conclusion

This chapter has provided background information about the measurement of the safety performance of firms. Data were reviewed about the measurement of work injuries and the measurement of occupational diseases. Newer techniques to measure and predict work injury and accident occurrence and potential, such as systems safety analysis, another technique of evaluating risks and value engineering, were discussed. Then information about cost-benefit analysis as applied to occupational safety and health was presented. Finally, studies of work injuries and illnesses directly related to this research were described.

## CHAPTER III

### RESEARCH METHODOLOGY AND LIMITATIONS

#### Introduction

The purpose of this chapter is to review the methodology and procedures followed in the research study and to discuss some of the limitations of this work.

After an analysis of the problem, it was concluded that the best way to estimate those factors which might tend to cause a reduction in occupational injuries and diseases was to empirically determine the practices of various organizations in order to attempt to measure and quantify them. Therefore, information was obtained by means of patterned interviews in order to obtain both information and increased sensitivity about the nature of the problem in the various operations studied. Information was also obtained by means of a mailed survey in order to obtain a larger sample and one distributed over a wider geographic area.

#### The Scope of the Study

The study was limited to organizations located in Texas because of the realistic restraints of available time and monies. A review of data about the Texas civilian labor force from the 1947-75 Texas Almanac (5) and from the Texas Department of Health report, Occupational Illnesses and Injuries in Texas 1972 and 1973 (75) indicated employment by major sector and lost workday incidence by major industrial grouping. These data are reported in Table 1.

Another way to examine the Texas labor force is to analyze it by principal geographic areas. This information is provided in Table 2.

The industrial grouping selected for further study was the manufacturing sector because of the large number of occupational injuries which occur in this sector, because practices in this sector tend to be somewhat more settled and because data in this sector were more readily attainable.

Three specific manufacturing industries were selected for further study. They were selected because they each represented a different facet of the manufacturing sector, because the researcher had some familiarity with them and because of their geographic location within the state. One of these is the chemical and allied products industry which was selected to be representative of manufacturers which have better than average safety performance as measured by the lost workday incident rate as reported both in Texas by the Texas Department of Health, Occupational Safety Division and nationally by the Bureau of Labor Statistics, U.S. Department

TABLE 1

Texas Civilian Labor Force Employment by Industrial Grouping and  
Lost Workday Incidence Rates as Computed Both by the  
State of Texas and the Federal Government by Industrial Grouping

| Industrial Grouping  | 1972<br>Employment<br>(000's<br>omitted) | Employment<br>as a Per-<br>cent of<br>the Total | 1972<br>Texas Lost<br>Workday<br>Case<br>Incident<br>Rate X 5* | 1972<br>National<br>Lost<br>Workday<br>Case<br>Incident<br>Rate X 5* |
|--|--|---|--|--|
| Agriculture, Forestry and<br>Fisheries                                   | 291                                      | 6%  | **   | **   |
| 16 Mining  | 102                                      | 2   | **   | 29   |
| Contract Construction  | 238                                      | 5   | 32   | 30   |
| Manufacturing  | 764                                      | 17  | 25   | 21   |
| Transportation, Com-<br>munication, Electric,<br>Gas & Sanitary Services | 253                                      | 6   | 24   | 22   |
| Wholesale and Retail<br>Trades   | 1165                                     | 25  | 15   | 14   |
| Finance, Insurance &<br>Real Estate                                      | 300                                      | 6   | 5  | 4  |

TABLE 1 (continued)

| Industrial Grouping                  | 1972<br>Employment<br>(000's<br>omitted) | Employment<br>as a Per-<br>Cent of<br>the Total | 1972<br>Texas Lost<br>Workday<br>Case<br>Incident<br>Rate X 5* | 1972<br>National<br>Lost<br>Workday<br>Case<br>Incident<br>Rate X 5* |
|--------------------------------------|--|---|--|--|
| Service Industries                   | 800                                      | 17  | 11   | 10   |
| Federal, State & Local<br>Government | <u>707</u>                               | <u>16</u>                                       | <u>**</u>  | <u>14</u>  |
| Total or Average                     | 4620                                     | 100%  | 18.5   | 16.5   |

\*Lost workday case incident rate times five is the number of lost workday cases per 100 full time workers multiplied times five to make this rate approximately equal to rates as computed by the ANSI Z 16.1 standard.

\*\*Not available

Sources: Belo Corporation, Texas Almanac and State Industrial Guide, 1974-1975 (Dallas: A.H. Belo Corporation, 1973); Texas Department of Health, Occupational Illnesses and Injuries in Texas 1972 and 1973 (Austin: Texas Department of Health, 1974); and U.S. Department of Labor, Occupational Injuries and Illnesses by Industry, 1972 (Washington, D.C.: Government Printing Office, 1974).

TABLE 2

Texas Civilian Labor Force Employment by  
Standard Metropolitan Statistical Area  
Geographic Subdivision  
1972

| Major Geographic Subdivisions<br>(Standard Metropolitan<br>Statistical Areas)                    | 1972<br>Employment<br>(000's omitted) | Percent<br>of the<br>Total |
|--|---------------------------------------|----------------------------|
| Houston - Beaumont - Galveston   | 1098                                  | 24%                        |
| Dallas - Ft. Worth - Sherman -<br>Denton   | 1116                                  | 24                         |
| Central Texas: San Antonio -<br>Austin - Waco - Killeen -<br>Temple - Bryan - College<br>Station | 590                                   | 13                         |
| South Texas: Brownsville -<br>Corpus Christi - Laredo -<br>McAllen                               | 245                                   | 5                          |
| West Texas: El Paso - Midland -<br>Odessa - San Angelo - Abilene -<br>Lubbock - Amarillo         | 400                                   | 8                          |
| East Texas: Tyler - Texarkana -<br>Longview - Marshall   | 121                                   | 3                          |
| Non-metropolitan labor force   | <u>1050</u>                           | <u>23</u>                  |
| Total  | 4620                                  | 100%                       |

Source: Belo Corporation, Texas Almanac and State  
Industrial Guide 1974-75 (Dallas: A. H. Belo  
Corporation, 1973).

of Labor. The second industry selected was the paper and allied products industry because its experience, according to these same measures of safety performance, was close to the average for the manufacturing sector. The third industry selected was lumber and wood products. Over the years this industry has sustained poorer than average work injury experience as measured by lost workday incidence rates. Further information about the three industries selected for study is located on Table 3.

### The Research Design

It was estimated that variations in work injury and illness rates and the cost of work injuries and illnesses were caused by three major factors. These factors were: (1) differences in the basic nature of various industries, (2) variations caused by the size of organizations as measured by the number of employees, and (3) variations in the practices and approaches to the problem of preventing work injury and illnesses by different firms. To account for these three possible sources of variation a 3 x 3 x 2 matrix was constructed and data were gathered for each cell of this matrix. A schematic representation of this matrix is shown in Figure 1.

### Determination of the Survey Universe and Sample

Information about the 341 Texas chemicals manufacturing facilities was obtained from the 1974 Director of Chemical Producers (71) prepared by Stanford Research Institute, from the 1974 Oil Directory of Texas and Production Survey (55) and from the Texas Railroad Commission 1973 Annual Report of the Oil and Gas Division (76). Similar information about the 1974 Directory of the Forest Products Industry (25), from Lockwood's Directory of the Paper and Allied Trades (46), and from the 1974 Directory of Texas Manufacturers (13). Data about wood products manufacturers in Texas were obtained from Crow's Buyers and Sellers Guide of the Forest Products Industry (20), from the Dunn and Bradstreet Middle Market Directory 1974 (48), from the Dunn and Bradstreet Million Dollar Directory, 1974 (49), and from the 1974 Directory of Texas Manufacturers (13). These sources provided the names, addresses and in some cases, demographic information about manufacturers in these three industries. Some further information about the three industries based on these references is located in Table 4.

Firms to be included in the survey were selected in two ways. In the paper industry, all known organizations in this industry were visited or were mailed a survey instrument. The chemicals and wood products firms to be included in the sample were selected proportionately based upon the following three factors: the size of the firm so that small, medium-sized and large firms were surveyed; the geographic subdivision in which firms were located; and the subclassification of industry classification, so that industrial chemicals firms and sawmills and planing mills were most frequently surveyed in order to increase the homogeneity of the sample.

### The Survey Instrument

A survey instrument was developed by carefully defining the questions it was designed to answer. It included questions about the development and

TABLE 3

Information about the Chemical, Paper and Wood  
Product Industries Located in Texas

| Industry                           | Employment<br>(000's<br>omitted) | Percent<br>of Texas<br>Labor<br>Force | Number<br>of Firms<br>in Texas | B.L.S.-<br>Lost<br>Workdays<br>Rate X 5* | Texas<br>Dept. of<br>Health<br>Lost<br>Workdays<br>Rate X 5* |
|------------------------------------|----------------------------------|---------------------------------------|--------------------------------|--|--|
| Chemical<br>and Allied<br>Products | 62                               | 1.3%                                  | 508                            | 14                                       | 14   |
| Paper and<br>Allied<br>Products    | 16                               | .4                                    | 264                            | 20.5                                     | 22   |
| Lumber and<br>Wood<br>Products     | <u>24</u>                        | <u>.5</u>                             | <u>884</u>                     | <u>46.5</u>                              | <u>44.5</u>  |
| Totals                             | 102                              | 2.2                                   | 1656                           |  |  |

\*Lost workday case incident rate times five is the number of lost workday cases per 100 full time workers multiplied times five to make this rate approximately equal to rates as computed by the ANSI 216.1 standard.

Sources: Belo Corporation, Texas Almanac and State Industrial Guide, 1974-75 (Dallas: A.H. Belo Corporation, 1973); U.S. Department of Labor, Occupational Injuries and Illnesses by Industry, 1972 (Washington, D.C.: Government Printing Office, 1974); and Texas Department of Health, Occupational Illnesses and Injuries in Texas, 1972 and 1973 (Austin: Texas Department of Health, 1974).

**FIGURE 1**

**The Research Design Which Measures Variation Caused by Industry, Size of Firm and Work Injury Frequency Rate**

| <b>Chemicals</b>             |                               | <b>Paper &amp; Allied Products</b> |                               | <b>Wood Products</b>         |                               |
|------------------------------|-------------------------------|------------------------------------|-------------------------------|------------------------------|-------------------------------|
| <b>Low Injury Freq. Rate</b> | <b>High Injury Freq. Rate</b> | <b>Low Injury Freq. Rate</b>       | <b>High Injury Freq. Rate</b> | <b>Low Injury Freq. Rate</b> | <b>High Injury Freq. Rate</b> |
| Small                        | Small                         | Small                              | Small                         | Small                        | Small                         |
| Medium                       | Medium                        | Medium                             | Medium                        | Medium                       | Medium                        |
| Large                        | Large                         | Large                              | Large                         | Large                        | Large                         |

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**Notes:** Low injury frequency rate refers to firms which have work injury frequency rates lower than the average rate for the industry.

High injury frequency rate refers to firms which have work injury rates higher than the average rate for the industry.

Small firms employed fewer than 50 full time employees in 1974.

Medium firms employed between 50 and 199 full time equivalent employees in 1974.

Large firms employed 200 or more full time equivalent employees in 1974.

TABLE 4

Numbers of Texas Chemicals, Paper and Wood Products  
Firms by Major Geographic Subdivision in the State

| Geographic Subdivision   | Numbers of Manufacturers |           |                  |
|--|--------------------------|-----------|------------------|
|  | Chemicals                | Paper     | Wood<br>Products |
| Houston - Beaumont -<br>Galveston  | 149                      | 33        | 11               |
| Dallas - Ft. Worth -<br>Sherman - Denton   | 35                       | 69        | 11               |
| Central Texas: San Antonio -<br>Austin - Waco - Killeen -<br>Temple - Bryan - College<br>Station | 12                       | 13        | 9                |
| South Texas: Brownsville -<br>Corpus Christi - Laredo -<br>McAllen                               | 26                       | 2         | 2                |
| West Texas: El Paso -<br>Midland - Odessa - San<br>Angelo - Abilene - Lubbock -<br>Amarillo      | 61                       | 4         | 7                |
| East Texas: Tyler -<br>Texarkana - Longview -<br>Marshall  | 21                       | 8         | 11               |
| Non-metropolitan labor force   | <u>37</u>                | <u>35</u> | <u>833</u>       |
| Total  | 341                      | 164       | 884              |

Sources: See (71), (55), (76), (25), (46), (13), (20),  
(48), and (49).

implementation of occupational safety and health programs and about the time and monies expended during the 1974 calendar year for various occupational safety and health control activities. These activities include top management activities, safety and health staff, new employee orientation and training, safety and health rules, activities to maintain interest in safety and health, safety meetings, safety and health inspections, the provision of personal protective equipment, the correction of unsafe physical conditions, physical examinations, injury treatment facilities and staff, off-the-job safety, safety training for experienced employees and records keeping activities. The instrument also asked respondents to indicate the relative effectiveness of these various activities by providing a rank ordering of them. Questions about the number of fatalities, lost workday injuries and illnesses, days lost, medical cases, first aid cases, manhours worked, injury frequency rates, injury severity rates, and costs of work injuries were included in order to measure performance.

Another portion of the instrument asked respondents to qualitatively evaluate the interest of top management, the design and layout of the location or workplace and housekeeping at the location.

Finally, in order to obtain basic demographic information, the survey instrument contained questions about products produced or work performed, the number and salaries of employees by major grouping, the age of the facility, the name of the workmen's compensation insurance carrier and the name of the labor union if any. A copy of the survey instrument is located in Appendix B.

#### Pre-Testing the Survey Instrument

The survey instrument was pre-tested by means of five patterned interviews conducted in January 1975. As a result of this pre-test, some changes in the wording of the instrument were made to clarify certain items. In addition, it was found during these first several interviews that the critical incident technique (originally included as a part of the survey in order to determine those factors judged by respondents to be most effective and least effective in reducing occupational injuries and illnesses) did not provide all of the information desired. Therefore, this information was obtained by means of a rank ordering of the variables which were included in the survey.

#### The Patterned Interviews

In order to obtain detailed answers to the questions asked from a substantial group of organizations and to increase sensitivity to the complexities of operations and of the problems in the industries studied 54 patterned interviews were conducted throughout the state in January, March, April, May and June 1975. Most interviews lasted from two to three hours so that there was enough time for full communication about the subjects discussed. Interviews followed the format of the survey instrument. After a brief explanation of the purpose of the interview to the person in charge of the safety program at the location visited, the interviewer asked the questions as they are stated on the survey instrument in the order that they appear on the instrument. Then respondents were asked what factors in their judgment made for effective safety and health performances and answers to this question were recorded verbatim. Finally, whenever possible, a brief tour of the operations visited

was made in order to obtain further perceptions and information about the nature of the firm visited.

Additional information about the interviews which were made can be found in Table 5. This table provides the number of interview visits made to small, medium and large sized firms as determined by the total number of employees in each firm surveyed. It also contains the number of firms by industry with work injury frequency rates which were lower or better than the industry average and those which were higher or poorer than the average rate for the industry.

### The Mailed Survey

In order to increase the sample size the instrument was also mailed to firms. This mailing to 570 selected Texas chemical, paper and wood products firms was made on April 2, 1975. The mailing consisted of a cover letter explaining the nature of the research being conducted, a printed copy of the survey instrument and a stamped, addressed return envelope. A copy of the cover letter is located in Appendix A.

By May 8, 1975, 67 completed surveys had been received, a 12.6% response rate. To improve this response rate a postal card reminder was sent to nonrespondents on that date. A copy of this follow up postal card is located in Appendix C. As a result of this reminder, by June 9, 1975, 95 useable responses had been received and a response rate of 17% had been attained. Additional information about the mailed responses received is located in Table 6. This table provides information about the number of mailed surveys received by industry, by the size of the firm and by whether the work injury rate of the respondent was above or below the average rate for the industry. Finally, both interview data and mailed survey data were combined and the total number of surveys reported by industry, size of firm and work injury frequency rate in Table 7.

In a number of cases surveys received were not complete. In these instances, the instrument was mailed back to the individual who completed the survey with the request that he provide additional information where indicated on the survey form. In a still fewer number of cases, complete information was not obtained even after this mailing. In these instances, the individual who completed the survey was telephoned and the needed information was obtained in this manner.

One of the incentives for participation in the study was that those respondents or interviewees who so requested were provided a summary of some of the major results of the study. This information was sent to these individuals on August 22, 1975.

### Assumptions Made in the Research

Many assumptions were made in this study as are made in all social research. However, several assumptions unique to this particular study have also been made. These are discussed below.

First, it has been assumed that the most appropriate way to measure the safety performance of an organization is to measure and estimate the total

TABLE 5

Number of Interviews Conducted by Industry  
Subdivision, Size of the Firm and by  
Work Injury Frequency Rate

| Size of Organization      | Low Work Injury Frequency Rate | High Work Injury Frequency Rate | Totals    |
|---------------------------|--------------------------------|---------------------------------|-----------|
| Chemicals                 |                                |                                 |           |
| Small                     | 3                              | 2                               |           |
| Medium                    | 2                              | 1                               |           |
| Large                     | <u>4</u>                       | <u>3</u>                        |           |
| Totals                    | 9                              | 6                               | 15        |
| Paper and Allied Products |                                |                                 |           |
| Small                     | 2                              | 1                               |           |
| Medium                    | 3                              | 2                               |           |
| Large                     | <u>4</u>                       | <u>4</u>                        |           |
| Totals                    | 9                              | 7                               | 16        |
| Wood Products             |                                |                                 |           |
| Small                     | 1                              | 4                               |           |
| Medium                    | 6                              | 5                               |           |
| Large                     | <u>3</u>                       | <u>4</u>                        |           |
| Totals                    | 10                             | 13                              | <u>23</u> |
| Grand Total               |                                |                                 | 54        |

Source: Analysis of data

TABLE 6

Number of Mailed Surveys Received by Industrial  
Subdivision, Size of the Firm and by Work  
Injury Frequency Rate Classification

| Size of<br>Organization   | Low Work Injury<br>Frequency Rate | High Work Injury<br>Frequency Rate | Totals    |
|---------------------------|-----------------------------------|------------------------------------|-----------|
| Chemicals                 |                                   |                                    |           |
| Small                     | 5                                 | 7                                  |           |
| Medium                    | 7                                 | 11                                 |           |
| Large                     | <u>8</u>                          | <u>3</u>                           |           |
| Totals                    | 20                                | 21                                 | 41        |
| Paper and Allied Products |                                   |                                    |           |
| Small                     | 3                                 | 6                                  |           |
| Medium                    | 5                                 | 5                                  |           |
| Large                     | <u>2</u>                          | <u>1</u>                           |           |
| Totals                    | 10                                | 12                                 | 22        |
| Wood Products             |                                   |                                    |           |
| Small                     | 8                                 | 7                                  |           |
| Medium                    | 1                                 | 3                                  |           |
| Large                     | <u>3</u>                          | <u>1</u>                           |           |
| Totals                    | 12                                | 11                                 | <u>23</u> |
| Grand Total               |                                   |                                    | 86        |

Source: Analysis of data

TABLE 7

Total Number of Interviews Conducted and Mailed Surveys  
Received by Industrial Subdivision, Size of the Firm  
and by Work Injury Frequency Rate Classification

| Size of Organization      | Low Work Injury Frequency Rate | High Work Injury Frequency Rate | Totals    |
|---------------------------|--------------------------------|---------------------------------|-----------|
| Chemicals                 |                                |                                 |           |
| Small                     | 8                              | 9                               |           |
| Medium                    | 9                              | 12                              |           |
| Large                     | <u>12</u>                      | <u>6</u>                        |           |
| Totals                    | 29                             | 27                              | 56        |
| Paper and Allied Products |                                |                                 |           |
| Small                     | 5                              | 7                               |           |
| Medium                    | 8                              | 7                               |           |
| Large                     | <u>6</u>                       | <u>5</u>                        |           |
| Totals                    | 19                             | 19                              | 38        |
| Wood Products             |                                |                                 |           |
| Small                     | 9                              | 11                              |           |
| Medium                    | 7                              | 8                               |           |
| Large                     | <u>6</u>                       | <u>5</u>                        |           |
| Totals                    | 22                             | 24                              | <u>46</u> |
| Grand Total               |                                |                                 | 140       |

Source: Analysis of data

cost of work injuries to the firm in monetary terms. This total cost would consist of the estimated direct insured cost of work injuries and illnesses, the additional cost of insurance premiums and an estimate of the noninsured, indirect cost of such work injuries.

Second, the most practical way to measure the various aspects of an occupational safety and health loss control program is to quantify them by measuring the cost of such expenditures and activities in monetary terms.

Third, the time frame selected for the study, safety activities during the calendar year 1974, and loss experience from calendar years 1972, 1973, and 1974 is representative of other past time periods and is hoped to be representative of other future time periods. The principal time period, 1974, is judged to be sufficiently distant from the events immediately following the passage of the Federal Occupational Safety and Health Act of 1970 so as to be representative of a relatively normal period of time. In addition, 1974 was a year of relatively stable economic conditions in Texas in spite of the severe inflation which occurred at that time.

#### Some Limitations of the Study

Because of the complexities of the business world as the many individuals in organizations act and react to factors both within the organization and outside its immediate boundaries there are real limitations to a study of this type. However, as Treat noted in his 1973 doctoral dissertation, such research with limitations "...properly delineated as such - is eminently preferable to no analysis at all."<sup>1/</sup>

With this thought in mind some of the possible limitations of this study will be reviewed. One of the major limitations of a research study of this type may be that those firms which did not respond to the mailing may be different than those firms which did respond to it. In order to attempt to reduce this potential problem, visits were made to five paper and eight wood products firms which did not respond to the mailed survey. For the most part, it was perceived during these interviews that the principal reason for nonresponse was the significant time judged by interviewees to be necessary to complete the instrument. One individual indicated that it would have taken him a week to complete the survey, although all information was obtained in a two hour interview.

A second possible problem with a research study of this type is that firms which have good safety records or with a low work injury frequency rate might respond significantly more frequently than those organizations whose safety records are poorer than industry averages. In this study this did not appear to be a problem because 70 of the participants in the study had better than industry average safety records and 70 of them had records which were poorer than the average for their industry.

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<sup>1/</sup> T. F. Treat, A Study of the Characteristics and Performance of Merging Hospitals in the United States (Ph.D. dissertation, Texas A&M University, 1973), p. 187, Ref. (80).

A third limitation to research of this sort is that participants may not provide complete or accurate information to the questions asked. The follow up procedures instituted in this study insured that complete information was obtained, but the degree of accuracy is not known. In two instances during the interviews the interviewer perceived that some of the data being supplied were subject to question. In these two cases, the interviewer rephrased the question at another point in the interview and received answers judged to be more accurate.

In some other cases, the person interviewed indicated that information provided was an estimate made to the best of his ability but was subject to error because full records were not available. It was judged that an estimate was preferred to a non-response because of the sample size.

A fourth possible limitation of the study might be bias on the part of the researcher which consciously or unconsciously might encourage interviewees and also respondents to the mailed instrument to provide information desired rather than accurate information. It is believed that this possible problem was minimized by means of the utilization of a neutral interview technique as described by Herbert H. Hyman in Survey Design and Analysis (41) and by Abraham Oppenheim in Questionnaire Design and Attitude Measurement (57) and by careful phrasing of questions on the survey instrument.

### Conclusion

In this chapter the scope of this study was described, the research design described, and the method of selecting the survey sample was outlined and information about the survey instrument was provided. Next, a description of the survey instrument and procedures followed to pre-test the instrument, perform patterned interviews and mail instruments was provided. Finally, some of the limitations of a study of this type were discussed and assumptions made in this study were described.

## CHAPTER IV

### DEMOGRAPHICS AND NON-QUANTITATIVE RESULTS OF THE RESEARCH

#### Introduction

The purpose of this chapter is to describe the qualitative results of the research conducted in order to test hypotheses about the relationship between activities and expenditures designed to reduce occupational injuries and illnesses and the injuries and illnesses which occur in selected Texas manufacturing industries. In this chapter data about respondents are compared to similar information about the survey universe. Demographic information about the respondents including a chi-square analysis of the qualitative data is also provided. In the concluding section of this chapter the results of the ranking of safety and health loss control activities are described. Last, some of the additional comments made by survey respondents are provided.

#### Comparison of Respondents to the Universe Sampled

One way of comparing the sample to the universe is to compare the number of respondents to the number of firms in each universe selected. Eleven percent of the chemicals industry firms, fourteen percent of the paper and allied products and five percent of all Texas wood products firms were included in this research. Table 8 provides this data.

A second way to evaluate respondent/universe relationships is to compare the number of employees in respondent firms to employees in the universe. This information, located in Table 9, shows that the firms surveyed employ twenty-nine percent of the employees in the industries selected for study.

#### Demographic Information about Respondents

Some general demographic information about respondents is now provided so that some of the major characteristics of participating organizations with respect to this study can be shown. The following information is provided for each industry studied by size of firm and by lost time injury frequency rate grouping:

- Employee number which is the number of all full time employees during 1974.
- Hourly rate which is the average hour rate of wages paid to hourly employees during 1974.
- Span of control, defined as the number of hourly employees for each first line supervisor. This measure was calculated

TABLE 8

Comparison of the Number of Survey Respondents  
to the Number of Texas Employers in  
Selected Manufacturing Industries

| Manufacturing Industry    | 1972 Number of Firms in Texas | Number of Respondents | Respondents as a Percent of all Firms |
|---------------------------|-------------------------------|-----------------------|---------------------------------------|
| Chemical                  | 508                           | 56                    | 11%                                   |
| Paper and Allied Products | 264                           | 38                    | 14%                                   |
| Wood Products             | <u>884</u>                    | <u>46</u>             | <u>5%</u>                             |
| Totals                    | 1656                          | 140                   | 8%                                    |

Sources: Belo Corporation, Texas Almanac and State Industrial Guide, 1974-75 (Dallas: A. H. Belo Corporation, 1973); various.

TABLE 9

Comparison of the Number of Employees in Respondent Firms to the Number of Employees in Selected Texas Manufacturing Industries

| Manufacturing Industry    | 1972 Number of Employees in Texas Firms | Number of Employees in Respondent Firms | Respondent Employees as a Percent of Texas Industry Employees |
|---------------------------|---|---|---|
| Chemical                  | 62,054                                  | 15,580                                  | 25%   |
| Paper and Allied Products | 16,426                                  | 7,556                                   | 46%   |
| Wood Products             | <u>23,919</u>                           | <u>6,922</u>                            | <u>29%</u>  |
| Totals                    | 102,399                                 | 30,058                                  | 29%   |

Sources: Belo Corporation, Texas Almanac and State Industrial Guide, 1974-75 (Dallas: A. H. Belo Corporation, 1973); various.

by dividing the number of hourly employees by the number of first line supervisory employees.

- Turnover or employee turnover as a percentage of total employees, which was computed by dividing the number of new employees added in 1974 by the total average number of employees.
- Profit which is profit as a percent of sales for firms. It was obtained from the Fortune magazine listing of this figure in May 1975 (27) and in June 1975 (26) and from Moody's Industrial Manual (52).
- Frequency rate which is the lost time injury frequency rate calculated as outlined in the ANSI Z16.1 standard (2).
- Severity rate or the lost time injury severity rate again calculated in accordance with the procedure described in the Z16.1 standard (2).

This information is provided in Tables 10, 11 and 12. It shows that there is a large difference between the average size grouping of firms studied as measured by number of employees. It also shows sizeable differences between the lost time injury frequency rates for each grouping, so that a distinct separation into cells by both size and by injury frequency rate did occur. Profit as a percent of sales was obtained from public documents whenever possible and included with this demographic information to provide another dimension to this description of the firms studied.

#### Analysis of Some Additional Information about Respondents

In addition to the key information presented in the previous section, other data obtained provided additional relevant information about firms surveyed.

These data were analyzed by the chi-square frequency statistical procedure by means of the North Carolina State University Statistical Analysis System on the Texas A&M University data processing system.

Major results of this analysis are provided in Table 13. These data indicate that there were no significant differences between those respondents with lower than average injury frequency rates and those with higher than average injury frequency rates based upon the factors discussed below. The first factor concerned the locus of the principal responsibility for the development of the safety and health program. The choices were "own staff", "corporate or headquarters", "insurance carriers", "outside consultants", or "other." No significant differences were found.

The second dimension measured was the quantity of safety rules provided by the location. Choices of "none," "a few general rules in an employee handbook," "many general rules in an employee handbook," "a few rules for specific jobs or work areas," "many rules for various specific jobs or work areas," and "other" were provided in the survey instrument. The first choice of respondents was selected as the appropriate response in this case. No significant

TABLE 11

Demographic Information about Paper and Allied  
Products Industry Respondents by Size of Firm  
and Work Injury Frequency Rate Classifications

| Size of Firm                       | Respondents<br>with Low Lost<br>Time Injury<br>Frequency Rate | Respondents<br>with High Lost<br>Time Injury<br>Frequency Rate |
|------------------------------------|---|--|
| Small (less than<br>50 employees)  |   |  |
| Employee No.                       | 23  | 28   |
| Hourly Rate                        | \$3.44  | \$3.54   |
| Span Control                       | 10.1  | 13.6   |
| Turnover                           | 24%   | 33%  |
| Profit                             | *   | *  |
| Frequency Rate                     | 4.40  | 36.50  |
| Severity Rate                      | 50.7  | 651.2  |
| Medium (50 to<br>199 employees)    |   |  |
| Employee No.                       | 116   | 93   |
| Hourly Rate                        | \$4.03  | \$3.90   |
| Span Control                       | 9.5   | 14.8   |
| Turnover                           | 18%   | 36%  |
| Profit                             | 6.7%  | 7.6%   |
| Frequency Rate                     | 8.80  | 52.15  |
| Severity Rate                      | 221.1   | 2377.0   |
| Large (more than<br>200 employees) |   |  |
| Employee No.                       | 718   | 273  |
| Hourly Rate                        | \$4.95  | \$3.60   |
| Span Control                       | 23.8  | 13.7   |
| Turnover                           | 14%   | 65%  |
| Profit                             | 7.3%  | 7.6%   |
| Frequency Rate                     | 10.84   | 26.86  |
| Severity Rate                      | 824.6   | 2255.9   |

\*Not able to be computed because all information was not available.

Source: Analysis of data, paper computer runs #20 and #26

TABLE 12

Demographic Information about Wood Products  
Industry Respondents by Size of Firm and  
Work Injury Frequency Rate Classification

| Size of Firm                       | Respondents<br>with Low Lost<br>Time Injury<br>Frequency Rate | Respondents<br>with High Lost<br>Time Injury<br>Frequency Rate |
|------------------------------------|---|--|
| Small (less than<br>50 employees)  |   |  |
| Employee No.                       | 24  | 29   |
| Hourly Rate                        | \$3.16  | \$2.66   |
| Span Control                       | 8.5   | 12.4   |
| Turnover                           | 43%   | 47%  |
| Profit                             | *   | *  |
| Frequency Rate                     | 3.53  | 77.97  |
| Severity Rate                      | 83.3  | 1367.7   |
| Medium (50 to<br>199 employees)    |   |  |
| Employee No.                       | 116   | 95   |
| Hourly Rate                        | \$2.92  | \$2.89   |
| Span Control                       | 19.7  | 13.8   |
| Turnover                           | 49%   | 54%  |
| Profit                             | *   | *  |
| Frequency Rate                     | 22.42   | 80.37  |
| Severity Rate                      | 639.5   | 1482.2   |
| Large (more than<br>200 employees) |   |  |
| Employee No.                       | 539   | 314  |
| Hourly Rate                        | \$3.51  | \$3.49   |
| Span Control                       | 10.6  | 16.4   |
| Turnover                           | 67%   | 97%  |
| Profit                             | 5.8%  | 7.2%   |
| Frequency Rate                     | 21.67   | 112.76   |
| Severity Rate                      | 1012.3  | 3112.7   |

\*Not able to be computed because all information was not available

Source: Analysis of data, wood computer runs #34 and #40

TABLE 13

The Probability That the Responses of Low and of High Work Injury Frequency Rate Respondent Evaluations of Selected Items Were Different as Measured by the Chi-Square Statistical Test

| Item                                  | Chemical | Paper | Wood Products |
|---------------------------------------|----------|-------|---------------|
| Safety and Health Program Development | .54      | .52   | .30           |
| Safety Rule Quantity                  | .49      | .55   | .73           |
| Age of Facility                       | .60      | .67   | .17           |
| Workmen's Compensation Insurance Co.  | .28      | .41   | .29           |
| Labor Union, if any                   | .23      | .47   | .32           |

Source: Analysis of data, correlations computer runs #16, #17 and #18

differences between firms with low work injury rates and those with high work injury rates in the three industries studies was found at a probability of .20 or less.

A third piece of information about respondents which was obtained was the age of the facility in years. In many cases this was an average figure because a number of facilities or locations had been constructed over a period of time, extensively added to or frequently changed. The ages of chemicals plants surveyed varied from less than one year old to more than fifty years old with a mode of 20-29 years of age. Paper plants similarly varied in ages from less than one year to more than fifty years with two equal modes of 5 to 9 and 10 to 14 years old occurring. Wood products locations also were from less than one year old to more than fifty years of age and their mode was also 20 to 29 years old. No significant differences because of the age of low and high frequency rate companies were found.

The fourth dimension reviewed in this section is the name of the workmen's compensation insurance company which insures the respondent. Again no statistically significant differences were determined by the chi-square test between those respondents with high and with low injury frequency rates. Information about the name of the workmen's compensation insurance company was coded as "not provided," "Texas Employers Insurance Company," "Liberty Mutual Insurance Company," "Texas General Indemnity Insurance," "Travelers," "Continental Insurance Company," "Highlands Insurance Agency," "Employers of Wausau," "The Kemper Group," and "all other insurance carriers." Once again no statistical differences between the two groups were found.

The fifth aspect reviewed in this analysis of data is the name of the labor union, if any. Again no statistical difference was found between those locations with low or high work injury frequency rates in the sample based upon this factor. Data from respondents were coded, "no union," "Oil, Chemical and Atomic Workers," "International Chemical Workers Union," "United Paperworkers, International," "International Brotherhood of Pulp, Sulphide and Paper Workers," "International Brotherhood of Teamsters," "International Union of Operating Engineers," "International Association of Machinists," "Building Trades," and "all other labor unions."

To summarize this section, one review of some of the information provided as a result of this survey did not provide any insights into the differences between low and high work injury firms but did provide some additional information about the respondents.

#### Analysis of Subjective Evaluations by Respondents

Survey participants were asked three questions which they answered subjectively or based on their judgment. A summary of the statistical results of answers to these three questions is located in Table 14.

First, the person in charge of the safety and health activities at locations surveyed was asked, "How would you characterize the interest of the top manager in safety and health?" Choices of "poor," "below average," "average," "above average," and "excellent" were provided. In both the chemicals and wood products industries those organizations with lower than average injury

TABLE 14

The Probability That the Responses of Low and of High Work Injury Frequency Rate Respondent Evaluations of Selected Subjective Evaluations Were Different as Measured by the Chi-Square Statistical Test

| Item                              | Chemical | Paper | Wood Products |
|-----------------------------------|----------|-------|---------------|
| Interest of Top Management        | .03      | .29   | .009          |
| Design and Layout of the Location | .02      | .28   | .72           |
| Housekeeping at the Location      | .59      | .34   | .53           |

Source: Analysis of data, correlations computer runs #16, #17 and #18

frequency rates reported more frequently that their top management had "above average" or "excellent" interest in the safety and health program based upon a chi-square test of frequency. In the paper industry this same tendency existed although not at a significant level of probability. Significance once again was defined as a probability of .20 or less.

The second of these subjective questions was, "How would you compare the design and layout of your location to other similar operations?" Once again, the choices of "poor," "below average," "average," "above average," and "excellent" were provided. In the chemical industry, lower injury frequency rate respondents indicated that the design and layout of their locations was significantly better than the responses made by high injury frequency rate participants. No significant differences in this chi-square test occurred in the paper and the wood products industries.

The third of these subjective questions was, "How would you compare the house-keeping at your location to other similar operations?" Possible choices were "poor," "below average," "average," "above average," or "excellent." Again, no significant differences were found.

In conclusion, reported "management interest in safety" did positively correlate with lower work injury experience in two of the three industries studied at better than the .05 level of probability.

#### Respondent Evaluations of the Effectiveness of Safety and Health Loss Control Activities

Another means of assessing the relative effectiveness of various safety and health activities was to ask respondents to provide a rank ordering of them. Question Number Nineteen asked, "Which activities do you believe most effectively reduce occupational injuries and illnesses at your location?" The question requested that respondents rank a listing of eighteen safety and health loss control activities in decreasing order.

The rank ordering of these activities by chemicals industry respondents with low injury frequency rates and with high injury frequency rates is provided in Table 15. This same information provided by paper industry respondents can be found in Table 16. Table 17 provides this information for wood product industry firms.

A visual inspection of these rank orders which represent the collective judgments of many experienced people in this field in Texas is of interest. This inspection shows that the following variables were judged to be most effective in reducing work injuries and illnesses: management or activities performed by top management; orientation of new employees; guarding or the correction of unsafe physical conditions; meetings about safety; inspections to find unsafe conditions and training for experienced employees. The following variables were judged to be moderately effective in reducing work injuries: staff or full-time and part-time people who provide staff assistance; equipment or personal protective equipment; rules about safety; investigations or injuries and illnesses; communication to employees about injuries and illnesses which have occurred and analysis of work injuries in order to determine some of their causes. A third series of variables were judged by respondents to be

TABLE 15

The Decreasing Rank Order of Activities Judged to Most Effectively Reduce Occupational Safety and Health Injuries and Illnesses as Ranked Both by High and by Low Injury Rate Respondents in the Chemical Industry

| Low Injury Frequency<br>Rate Respondents | High Injury Frequency<br>Rate Respondents |
|--|---|
| 1 Management                             | 1 Orientation                             |
| 2 Orientation                            | 2 Meetings                                |
| 3 Guarding                               | 3 Guarding                                |
| 4 Meetings                               | 4 Management                              |
| 5 Inspections                            | 5 Equipment                               |
| 6 Training                               | 6 Inspections                             |
| 7 Staff                                  | 7 Training                                |
| 8 Equipment                              | 8 Staff                                   |
| 9 Rules                                  | 9 Rules                                   |
| 10 Investigations                        | 10 Investigations                         |
| 11 Communication                         | 11 Communication                          |
| 12 Analysis                              | 12 Physicals                              |
| 13 Publications                          | 13 Analysis                               |
| 14 Posters                               | 14 Publications                           |
| 15 Physicals                             | 15 Posters                                |
| 16 Medical                               | 16 Records                                |
| 17 Off-the-Job                           | 17 Medical                                |
| 18 Records                               | 18 Off-the-Job                            |

Source: Analysis of data, correlations computer run #21

TABLE 16

The Decreasing Rank Order of Activities Judged to Most Effectively Reduce Occupational Safety and Health Injuries and Illnesses as Ranked Both by High and by Low Injury Rate Respondents in the Paper Industry

| Low Injury Frequency<br>Rate Respondents | High Injury Frequency<br>Rate Respondents |
|--|---|
| 1 Meetings                               | 1 Management                              |
| 2 Management                             | 2 Guarding                                |
| 3 Orientation                            | 3 Inspections                             |
| 4 Guarding                               | 4 Meetings                                |
| 5 Inspections                            | 5 Orientation                             |
| 6 Communication                          | 6 Rules                                   |
| 7 Rules                                  | 7 Equipment                               |
| 8 Equipment                              | 8 Communication                           |
| 9 Training                               | 9 Investigations                          |
| 10 Investigations                        | 10 Training                               |
| 11 Staff                                 | 11 Posters                                |
| 12 Analysis                              | 12 Staff                                  |
| 13 Publications                          | 13 Medical                                |
| 14 Physicals                             | 14 Physicals                              |
| 15 Posters                               | 15 Analysis                               |
| 16 Medical                               | 16 Records                                |
| 17 Records                               | 17 Publications                           |
| 18 Off-the-Job                           | 18 Off-the-Job                            |

Source: Analysis of data, correlations computer run #22

TABLE 17

The Decreasing Rank Order of Activities Judged to Most Effectively Reduce Occupational Safety and Health Injuries and Illnesses as Ranked both by High and by Low Injury Rate Respondents in the Wood Product Industry

| Low Injury Frequency<br>Rate Respondents | High Injury Frequency<br>Rate Respondents |
|--|---|
| 1 Orientation                            | 1 Guarding                                |
| 2 Management                             | 2 Orientation                             |
| 3 Guarding                               | 3 Management                              |
| 4 Meetings                               | 4 Inspections                             |
| 5 Inspections                            | 5 Meetings                                |
| 6 Communication                          | 6 Training                                |
| 7 Equipment                              | 7 Equipment                               |
| 8 Training                               | 8 Rules                                   |
| 9 Rules                                  | 9 Staff                                   |
| 10 Investigations                        | 10 Investigations                         |
| 11 Staff                                 | 11 Communication                          |
| 12 Physicals                             | 12 Physicals                              |
| 13 Analysis                              | 13 Medical                                |
| 14 Medical                               | 14 Analysis                               |
| 15 Posters                               | 15 Records                                |
| 16 Publications                          | 16 Posters                                |
| 17 Records                               | 17 Publications                           |
| 18 Off-the-Job                           | 18 Off-the-Job                            |

Source: Analysis of data, correlations computer run #22

least effective. These variables are: publications on the subject of safety; posters about safety; physicals or the provision of both pre-employment and periodic physical examinations; medical supplies, facilities and staff provided to treat work injuries and illnesses; records maintained about injuries and illnesses and off-the-job or activities designed to reduce employee injuries off-the-job or away from work.

One limitation of this rank ordering of safety activities should be pointed out. Because of a clerical error contests was not included in this list of activities. Contents was defined in this study as national and organization devised contests and as the provision of monetary incentives to encourage employee safety. Based upon the interviews made it is estimated by the author that this activity would have received a mid-rating by both low and high frequency rate respondents.

A second way to compare the rank order of loss control activities is by means of Spearman's coefficient of rank correlation. This coefficient is defined as the sum of the squared differences in the paired ranks divided by what the sum of the squared differences would have been if the two sets of ranking had been totally independent (54). This test was made by comparing data supplied by low and high injury frequency rate respondents to each other for each of the three industries studied. In each of these industries there was no significant difference between the ranking of variables by low injury rate firms and by high injury rate firms. In each case the probability was less than .001. Therefore, both low and high injury respondents essentially agree on the relative importance of various safety and health loss control activities.

#### Additional Comments about the Reduction of Occupational Safety and Health Losses Made by Respondents

One last non-quantitative evaluation of the effectiveness of various activities designed to reduce the control occupational injuries and illnesses was comments made by the respondents during the course of their interviews.

Comments made by individuals in the chemical industry are presented first. The safety supervisor at a large chemical plant which had an exceptionally low work injury frequency rate indicated that "Employee responsibility and Theory Y, open management, accounted for the record." The safety engineer at another large chemical plant indicated that major factors at his location causing a good record to occur were that "Safety is a line function. The company is goal oriented and employees' attitudes toward the achievement of goals is good, a feedback system is used, the plant is in good physical condition..." and that "major problems are the pace of change and people." A third individual at a large chemical plant with a good record indicated that key factors were "company philosophy - people are the most important asset...employee contacts, multiple meetings, and management support." The safety coordinator at still another large plant emphasized the plant off-the-job safety program stating that "good on-the-job experience improves with an off-the-job safety program." Another stated, "Safety rules are very important." Another indicated that in 1974 "a program of two hours of training for all employees in the use and application of all respiratory equipment and closed pulmonary resuscitation... was the most beneficial program we had in accident prevention. All employees actually put on equipment and practiced closed pulmonary resuscitation."

Another said that improved performance was caused by "open management style and straightforward...strong and good labor-management relations...and enforcement of safety rules" and that "confidence has been gained as (physical) conditions have been improved to make sure that the employees know that the company has their interests at heart." The safety supervisor at another plant added, "the line supervisors (safety activities) should be (ranked) number two in importance to the safety of employees, immediately after top management activities." The individual charged with the safety responsibility at another location indicated that, "the greatest effort has to be in the training of people and increasing knowledge of the operations...if done right, work can be safe here. Fundamentals should be stressed; assume no knowledge." One last individual at a large chemicals plant stated, "The main thing is participation of first line supervisors in the program - a key ingredient. Employee attitude should be controlled better and we need a way to do this."

One respondent with a medium-sized chemical industry firm indicated that the key to a successful safety record is "a push from the operating corporate group who insists on good performance and who push local management...the program must come from the top down" and that "attitudes will be what the bosses' are." Another made a similar comment when he stated, "Management backing is very important in helping develop proper attitudes and promoting equipment." Still another indicated, "We are experiencing a substantial improvement in the safety program. This is due to extra effort by safety engineers and additional management interest." Finally, an industrial relations supervisor said, "Motivation and training is primary" and a safety supervisor summed it up as "common sense."

One individual with a small chemical firm indicated that in his judgment, "safety depends upon the desire of the employee to have safe work practices." The office manager in another small firm said that the "safety awards program (is) very effective." A plant manager said, "Common sense is the key, not Washington rules. We must sell management. Safety is very important. We must analyze (problems) and do what is necessary."

Additional comments were also made by individuals heading safety activities and/or operations at large paper and allied products plants. One stated that "the foreman - employee relationship is the key." Another discussing a new activity at his location said, "Significant confidence is placed in the organization development technique being implemented at the plant (which is) designed to open and improve communications and to change employee attitudes." Others said, "Safety is an attitude," most important is the "backing of all levels of management and participation because it is not a one-man job," and most important are "five minute safety talks." The individual heading another program stated that the most important safety activities are "foremen meeting weekly with their employees, the plant managers' involvement and interest, safety rules and regulations and a green stamp (incentives) program which involves the people." Still another stated that most important were "participation by management and supervisory personnel (and) employee interest in safety and concern." The plant superintendent of a medium-sized paper plant said, "the personal factor, the employee, is the key." A staff member at another medium-sized location indicated that, "all (of the various parts of a safety program) work together" to achieve performance. At another location the personnel manager said, "Safety is a mental attitude."

In the wood products industry, survey participants also provided additional comments both by means of mailed surveys and during interviews made. One individual stated that, "employee education is the key." Another indicated that "management's sincere concern and support is the key to safety... inspections save many injuries" and that a "new addition (regarding safety) to employee orientation is good." A well-seasoned individual said that injuries and illnesses are reduced by "a combination of several things, including the attitudes of employers and employees and an incentive program." At another plant the most effective activities were reported to be, "foremen meetings with crews, and safety drawings which encourage people to get the right attitude and work habits." The personnel manager at another plant stated that best were "top management interest and commitment (which) creates the climate, agreement and participation of employees and enforcement by peers, films showing the impact of injuries on men geared to the men in the plant to effectively communicate and the blindfolded man program to increase safety glass useage." The general manager of a medium-sized firm said, "Safety is a necessity here. Department heads push safety or hit the road. 98% of all accidents are due to a mental blank." Judged most effective by the plant superintendent of another medium-sized sawmill were, "meetings with employees, meetings with foremen and making men aware of what you are trying to do." An officer in another medium-sized company stated, "Employee carelessness is the major problem. The plant is not perfect but an accident-proof plant would not be productive. With the people in this work you can't do much to train them." The plant superintendent at another location said, "a good safety program is useful and important, wish one existed at this location... many injuries occur with the newer employees." The plant manager at another medium-sized sawmill stated that "orientation of people is the key, awareness and involvement." The vice-president of production at another wood products firm said, "If new employees are properly instructed this is the key - you must explain hazards." "It takes effort and repetition" stated another vice-president, "to get through to people so they understand the importance of safety - you must keep plugging at it." A lumber company head concluded an interview by saying, "if a man wants to get hurt he will get hurt" and that "faked back injuries are a problem." A supervisor and safety director at a small firm stated, "Our work is in a hazardous industry - we try to do our level best to protect our employees from injuries and illnesses." The head of another small firm said, "An ounce of prevention is worth a pound of cure - you must use different approaches on different people." Finally, the head of another small operation said, "I caution my men personally while working."

### Conclusion

In conclusion, demographic information about respondents has been presented and non-quantitative aspects of the research provided. A review of the rank ordering of safety and health loss control variables by those surveyed was reviewed and this information was compared by means of the Spearman's rho statistical test. Finally, general comments by respondents were provided in order to provide further insights about the subject.

## CHAPTER V

### QUANTITATIVE RESULTS OF THE RESEARCH

#### Introduction

This chapter describes the quantitative results of the research which tests hypotheses about the relationship between activities and expenditures designed to reduce occupational injuries and illnesses and those injuries and illnesses which occur in selected Texas manufacturing industries. Information about the monetary cost of occupational safety and health loss control activities to the firms in selected industries is presented first. Then data about the monetary cost of work injuries and illnesses to these firms is provided. Next the results of a maximum  $R^2$  improvement multiple linear regression computation of the effect of selected variables upon the safety performance of firms as measured by the monetary cost of losses is described. Finally, the results of this quantitative study are reviewed and analyzed.

#### The Cost of Occupational Safety and Health Loss Control Activities

The monetary cost of the loss control activities of survey respondents by firms has been computed for both firms with high and low work injury frequency rates grouped by size and by industry. The results of these calculations performed by the utilization of the North Carolina State University Statistical Analysis System on the Texas A&M University computer system are provided in Tables 18-26. These average cost figures have been stated in terms of dollars per employee so they could be on a comparable basis with each other and with the monetary cost of work injuries and illnesses. They can be converted to the dollar costs to an organization of a given size by being multiplied by the number of employees in the firm. Each of the occupational safety and health loss control activities or variables provided has been computed from information provided by survey respondents by means of a computer program.

"Management" or safety and health related activities performed by the top manager at the location was calculated by multiplying the approximate average annual income of managers and staff by the time spent by the top manager in 1974 on safety and health in terms of a percent of total time available. This is not an ideal way to evaluate the activities of top management but is the best quantitative measure which could be devised. The variable "staff" consists of the activities of full and part-time safety and health personnel in the organization. Its monetary cost in 1974 consisted of the total annual salaries of full time safety and health personnel plus the total annual salaries of each part-time safety and health staff member times the percent of time that individual spent on safety and health activities. The variable "orientation" is the cost of orienting and training each new employee in

TABLE 18

The Cost of Safety Activities for Small  
Chemical Firm Respondents

| Firms with<br>Low Lost Time<br>Injury Frequency Rate |               | Firms with<br>High Lost Time<br>Injury Frequency Rate |               |
|--|---------------|---|---------------|
| Activity   | Cost/Employee | Activity  | Cost/Employee |
| Guarding   | \$153         | Guarding  | \$310         |
| Meetings   | 71            | Meetings  | 83            |
| Equipment  | 48            | Staff   | 61            |
| Staff  | 24            | Equipment   | 52            |
| Management   | 19            | Orientation   | 33            |
| Orientation  | 19            | Management  | 24            |
| Physicals  | 12            | Inspections   | 20            |
| Inspections  | 22            | Training  | 15            |
| Interest   | 11            | Interest  | 15            |
| Rules  | 11            | Rules   | 14            |
| Medical  | 11            | Physicals   | 9             |
| Records  | 6             | Medical   | 6             |
| Off-the-Job  | 4             | Records   | 2             |
| Training   | <u>3</u>      | Off-the-Job   | <u>1</u>      |
| <b>Total</b>   | <b>\$414</b>  | <b>Total</b>  | <b>\$645</b>  |

Source: Analysis of data, chemical, computer run #7

TABLE 19

The Cost of Safety Activities for Medium-Sized  
Texas Chemical Firm Respondents

| Firms with<br>Low Lost Time<br>Injury Frequency Rate |               | Firms with<br>High Lost Time<br>Injury Frequency Rate |               |
|--|---------------|---|---------------|
| Activity   | Cost/Employee | Activity  | Cost/Employee |
| Guarding   | \$170         | Guarding  | \$354         |
| Staff  | 104           | Staff   | 63            |
| Meetings   | 78            | Equipment   | 59            |
| Equipment  | 55            | Meetings  | 36            |
| Medical  | 21            | Interest  | 29            |
| Training   | 18            | Physicals   | 16            |
| Physicals  | 13            | Orientation   | 14            |
| Orientation  | 9             | Inspections   | 13            |
| Inspections  | 8             | Medical   | 10            |
| Interest   | 5             | Training  | 12            |
| Management   | 4             | Management  | 9             |
| Records  | 3             | Records   | 4             |
| Rules  | 3             | Rules   | 3             |
| Off-the-Job  | 2             | Off-the-Job   | 2             |
| <b>Total</b>   | <b>\$493</b>  | <b>Total</b>  | <b>\$624</b>  |

Source: Analysis of data, chemical, computer run #7

TABLE 20

The Cost of Safety Activities for Large  
Texas Chemical Firm Respondents

| Firms with<br>Low Lost Time<br>Injury Frequency Rate |               | Firms with<br>High Lost Time<br>Injury Frequency Rate |               |
|--|---------------|---|---------------|
| Activity   | Cost/Employee | Activity  | Cost/Employee |
| Guarding   | \$325         | Guarding  | \$303         |
| Meetings   | 82            | Meetings  | 147           |
| Equipment  | 74            | Staff   | 110           |
| Orientation  | 65            | Equipment   | 45            |
| Staff  | 56            | Medical   | 35            |
| Medical  | 49            | Training  | 21            |
| Training   | 29            | Physicals   | 20            |
| Physicals  | 21            | Records   | 10            |
| Inspections  | 20            | Inspections   | 10            |
| Interest   | 15            | Orientation   | 8             |
| Records  | 11            | Interest  | 6             |
| Off-the-Job  | 4             | Management  | 3             |
| Rules  | 4             | Rules   | 1             |
| Management   | <u>2</u>      | Off-the-Job   | <u>1</u>      |
| <b>Total</b>   | <b>\$757</b>  |   | <b>\$720</b>  |

Source: Analysis of data, chemical, computer run #7

TABLE 21

The Cost of Safety Activities for Small  
Texas Paper Product Firm Respondents

| Firms with<br>Low Lost Time<br>Injury Frequency Rate |               | Firms with<br>High Lost Time<br>Injury Frequency Rate |               |
|--|---------------|---|---------------|
| Activity   | Cost/Employee | Activity  | Cost/Employee |
| Guarding   | \$155         | Guarding  | \$211         |
| Staff  | 39            | Meetings  | 28            |
| Inspections  | 20            | Staff   | 26            |
| Equipment  | 20            | Management  | 24            |
| Management   | 11            | Inspections   | 13            |
| Meetings   | 11            | Medical   | 12            |
| Orientation  | 9             | Equipment   | 11            |
| Medical  | 7             | Orientation   | 7             |
| Physicals  | 3             | Physicals   | 6             |
| Records  | 2             | Rules   | 3             |
| Training   | 1             | Records   | 2             |
| Interest   | 1             | Interest  | 1             |
| Rules  | 1             | Off-the-Job   | 1             |
|  |               | Training  | 1             |
| <b>Total</b>   | <b>\$280</b>  |   | <b>\$346</b>  |

Source: Analysis of data, paper, computer run #12

TABLE 22

The Cost of Safety Activities for Medium-Sized  
Texas Paper Product Firm Respondents

| Firms with<br>Low Lost Time<br>Injury Frequency Rate |               | Firms with<br>High Lost Time<br>Injury Frequency Rate |                   |
|--|---------------|---|-------------------|
| Activity   | Cost/Employee | Activity  | Cost/Employee     |
| Guarding   | \$ 52         | Guarding  | \$ 83             |
| Staff  | 24            | Orientation   | 17                |
| Meetings   | 24            | Staff   | 14                |
| Inspections  | 22            | Physicals   | 10                |
| Interest   | 17            | Meetings  | 7                 |
| Physicals  | 11            | Medical   | 6                 |
| Equipment  | 11            | Inspections   | 6                 |
| Medical  | 6             | Equipment   | 4                 |
| Training   | 4             | Interest  | 3                 |
| Orientation  | 4             | Management  | 2                 |
| Management   | 4             | Records   | 2                 |
| Records  | 4             | Rules   | 1                 |
| Rules  | 2             | Training  | 1                 |
| Off-the-Job  | <u>1</u>      |   | <u>          </u> |
| <b>Total</b>   | <b>\$187</b>  |   | <b>\$156</b>      |

Source: Analysis of data, paper, computer run #12

TABLE 23

The Cost of Safety Activities for Large  
Texas Paper Product Firm Respondents

| Firms with<br>Low Lost Time<br>Injury Frequency Rate |               | Firms with<br>High Lost Time<br>Injury Frequency Rate |               |
|--|---------------|---|---------------|
| Activity   | Cost/Employee | Activity  | Cost/Employee |
| Guarding   | \$ 98         | Guarding  | \$344         |
| Meetings   | 25            | Medical   | 53            |
| Staff  | 21            | Staff   | 34            |
| Medical  | 19            | Physicals   | 26            |
| Equipment  | 14            | Equipment   | 16            |
| Interest   | 6             | Training  | 16            |
| Inspections  | 4             | Meetings  | 12            |
| Physicals  | 4             | Orientation   | 9             |
| Records  | 4             | Inspections   | 6             |
| Training   | 3             | Records   | 3             |
| Orientation  | 2             | Management  | 2             |
| Off-the-Job  | 2             | Interest  | 2             |
| Management   | 1             | Off-the-Job   | 1             |
| Rules  | <u>---</u>    | Rules   | <u>1</u>      |
| <b>Total</b>   | <b>\$203</b>  |   | <b>\$525</b>  |

Source: Analysis of data, paper, computer run #12

TABLE 24

The Cost of Safety Activities for Small  
Texas Wood Product Firm Respondents

| Firms with<br>Low Lost Time<br>Injury Frequency Rate |               | Firms with<br>High Lost Time<br>Injury Frequency Rate |               |
|--|---------------|---|---------------|
| Activity   | Cost/Employee | Activity  | Cost/Employee |
| Guarding   | \$ 89         | Guarding  | \$231         |
| Meetings   | 20            | Staff   | 20            |
| Staff  | 9             | Equipment   | 8             |
| Management   | 8             | Medical   | 5             |
| Inspections  | 5             | Management  | 5             |
| Equipment  | 4             | Inspections   | 3             |
| Medical  | 4             | Meetings  | 3             |
| Rules  | 3             | Orientation   | 2             |
| Orientation  | 3             | Interest  | 2             |
| Physicals  | 3             | Records   | 2             |
| Interest   | 1             | Physicals   | 1             |
| Records  | 1             | Rules   | 1             |
| Training   | 1             | Off-the-Job   | 1             |
|  |               | Training  | 1             |
| <b>Total</b>   | <b>\$151</b>  |   | <b>\$285</b>  |

Source: Analysis of data, wood, computer run #9

TABLE 25

The Cost of Safety Activities for Medium-Sized  
Texas Wood Product Firm Respondents

| Firms with<br>Low Lost Time<br>Injury Frequency Rate |               | Firms with<br>High Lost Time<br>Injury Frequency Rate |               |
|--|---------------|---|---------------|
| Activity   | Cost/Employee | Activity  | Cost/Employee |
| Guarding   | \$ 52         | Guarding  | \$135         |
| Staff  | 16            | Staff   | 29            |
| Meetings   | 11            | Meetings  | 11            |
| Equipment  | 8             | Orientation   | 9             |
| Physicals  | 6             | Equipment   | 9             |
| Management   | 5             | Management  | 7             |
| Orientation  | 3             | Physicals   | 6             |
| Inspections  | 2             | Medical   | 5             |
| Medical  | 2             | Inspections   | 5             |
| Interest   | 2             | Records   | 3             |
| Rules  | 2             | Interest  | 1             |
| Records  | 1             | Rules   | 1             |
| Training   | <u>1</u>      | Training  | <u>---</u>    |
| Total  | \$111         |   | \$221         |

Source: Analysis of data, wood, computer run #9

TABLE 26

The Cost of Safety Activities for Large  
Texas Wood Product Firm Respondents

| Firms with<br>Low Lost Time<br>Injury Frequency Rate |               | Firms with<br>High Lost Time<br>Injury Frequency Rate |               |
|--|---------------|---|---------------|
| Activity   | Cost/Employee | Activity  | Cost/Employee |
| Guarding   | \$ 51         | Guarding  | \$113         |
| Meetings   | 29            | Physicals   | 33            |
| Staff  | 14            | Staff   | 20            |
| Interest   | 9             | Meetings  | 13            |
| Equipment  | 9             | Training  | 11            |
| Medical  | 9             | Orientation   | 9             |
| Inspections  | 8             | Equipment   | 9             |
| Physicals  | 7             | Medical   | 4             |
| Orientation  | 5             | Records   | 3             |
| Rules  | 1             | Interest  | 3             |
| Records  | 1             | Management  | 2             |
| Off-the-Job  | 1             | Inspections   | 1             |
| Training   | 1             | Off-the-Job   | 1             |
| Management   | <u>1</u>      |   |               |
| <b>Total</b>   | <b>\$146</b>  |   | <b>\$222</b>  |

Source: Analysis of data, wood, computer run #9

regard to safety and health during 1974. Its cost is the sum of the results of multiplying the orientation time per employee times the number of new employees during 1974 times the average rate for hourly or non-exempt employees plus the orientation time per employee times the number of new employees during 1974 times the hourly rate of the individual doing the orientation. The factor labeled "rules" is the estimated cost of preparing and distributing safety and health rules during 1974. This figure was obtained from question number six on the survey instrument. The next item, "interest," is those activities performed to maintain interest in safety and health. Its 1974 dollar cost is the total of respondent costs to participate in national or regional safety contests or organization devised safety contests, to purchase and distribute safety publications, to purchase and display safety posters and to establish other miscellaneous activities to interest employees in safety as awards, incentives such as scoreboards, bulletin boards, sign boards, dinners and banquets, special programs (such as safety days or weeks), company bulletins and newspapers, and safety seminars, trips and conferences. The variable "meetings" consists of those department or employee, supervisory, management, labor-management and other safety meetings held. The cost of meetings in 1974 was determined by multiplying the number of meetings held in 1974 times the average meeting length in minutes times the average number of people attending each meeting times the hourly rate for the people attending each of the various types of meetings held and then adding these costs together in order to determine the total dollar cost of safety meetings. "Inspections" are safety and health inspections made during 1974 by the safety and health staff, first line supervisors, other management personnel, corporate or headquarters staff, insurance carrier staff members, state or local governmental inspectors, federal governmental officials or by others such as consultants, non-exempt employees, contract maintenance people, outside safety inspection service company personnel, labor-management inspection teams, or by safety committee members. The cost of inspections in 1974 was determined by multiplying the number of inspections made in 1974 times the average time spent per inspection in minutes times the average number of organization people making the inspections or accompanying people from outside the organization on their inspections times the hourly rate for these people within the organization for each type of inspection plus direct fees assessed by outside firms. The cost of all inspections was then determined by adding together the cost of the various types of inspections performed in 1974. The next item, "equipment," is the cost of personal protective equipment provided and paid for by firms during 1974. The cost of this equipment was calculated by multiplying the number of items furnished times a standardized unit cost. Classifications of personal protective equipment used are hard hats, prescription safety glasses, plano safety glasses, goggles, face shields, respirators, safety shoes, ear plugs, ear muffs, protective clothing, gloves, gas masks, dust respirators and masks, rubber boots, aprons, respirator cartridges, self-contained breathing apparatus, air line respirators, welder's helmets, coveralls, uniforms and miscellaneous. Standardized unit costs for each of these items were determined from cost information supplied by some respondents, a review of safety equipment catalogs and conversations with representatives of major safety equipment suppliers in Texas. "Guarding" is 1974 monetary expenditures to correct unsafe physical conditions which could affect employee safety and health. "Physicals" consists of various physical examinations provided by the firm. These consist of physical examinations given to prospective employees, periodic physical examinations given

to employees at time intervals and "other" physical examinations given to employees when they return to work after recovery from an occupational injury, after a personal illness or to employees in certain departments or to special employees. The 1974 cost of these physicals was determined by adding together the cost of preemployment, periodic and other physical examinations. "Medical" consists of medical supplies, facilities and staff made available by firms to treat work injuries and illnesses. The 1974 medical costs consist of the cost of organization-provided first aid kits, first aid rooms, dispensaries and hospitals plus the number of organization people who treat employee injuries and illnesses times the percent of time they spent treating such occurrences times the annual salaries of such individuals. "Off-the-Job" or OTJ is those activities designed to reduce employee injuries off-the-job or away from work. These activities typically consist of educational safety meetings on the subject held before holidays or vacations, bulletins and contests to stimulate awareness of and interest in the subject and the maintenance and communication of information about those injuries which do occur to employees while they are off-the-job. The cost of off-the-job safety is the monies expended by respondents during 1974 in this area. "Training" consists of activities other than those elsewhere listed to train experienced employees in safety and health. These activities generally consist of first aid training which normally provides both information about the prevention of injuries and about the treatment of injuries, the training of fork lift truck drivers, driver training, general safety training, special safety training as in regard to emergencies, the use of self-contained breathing apparatus, job safety analyses made to identify those hazards which might be a part of various jobs, correspondence courses, seminars, conferences, meetings, employee contact programs and the use of consultants to train employees. The cost of these activities during 1974 consists of the time employees spent in these activities times the number of organization people involved times the hourly rate for the people involved plus the cost of other safety and health activities as requested by question number 17 on the survey instrument. Finally, information about "records" has been obtained from survey respondents. This item consists of the maintenance of records of lost time cases, doctor or medical cases and first aid cases, the investigation of injuries, accidents and near miss occurrences, analyses of injuries and illnesses in order to try to determine trends, reports to management about injuries and illnesses and reports or communication to employees about work injuries and illnesses.

The "safety total" is the total of the cost of each of the activities or variables previously described. This total and the cost of each of these activities or variables has been computed in dollars per employee by dividing the safety total or the appropriate variable by the appropriate total number of employees for each firm or grouping of firms included in this study.

Information about the costs of those occupational safety and health activities designed to reduce work injuries and illnesses may be clearer in graphic form, and so has been presented in this form. Figures two to ten provide circular or pie charts comparing the average money expended per employee during 1974 for both low work injury rate firms and for high work injury rate firms. These charts have been prepared for firms of each of three size groupings for each industry studied. Once again, small firms are defined in this study as those with an average of less than 50 full time employees during 1974, medium-sized firms are those with between 50 and 199 full time employees during 1974, and large firms are those with more than 200 full time employees during 1974.

Figure 2

The Cost of Safety Activities by Percent of the Total Cost in Terms of Dollars Spent Per Employee for Small Texas Chemical Firm Respondents

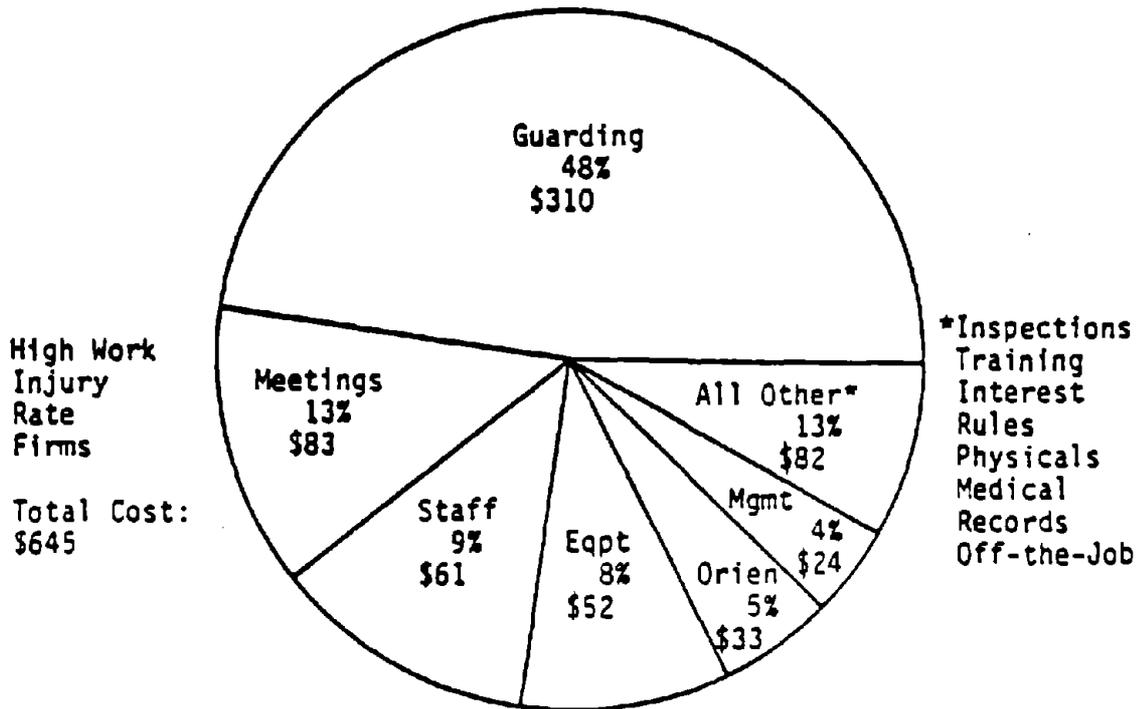
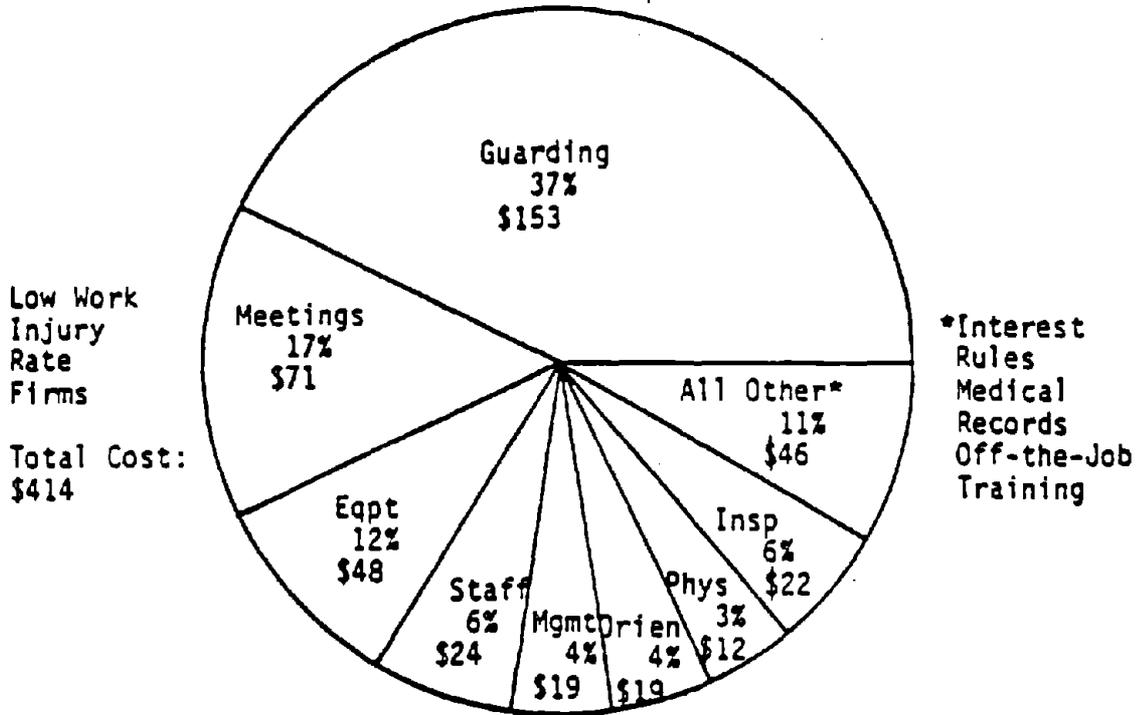


Figure 3

The Cost of Safety Activities by Percent of the Total Cost in Terms of Dollars Spent Per Employee for Medium-Sized Texas Chemical Firm Respondents

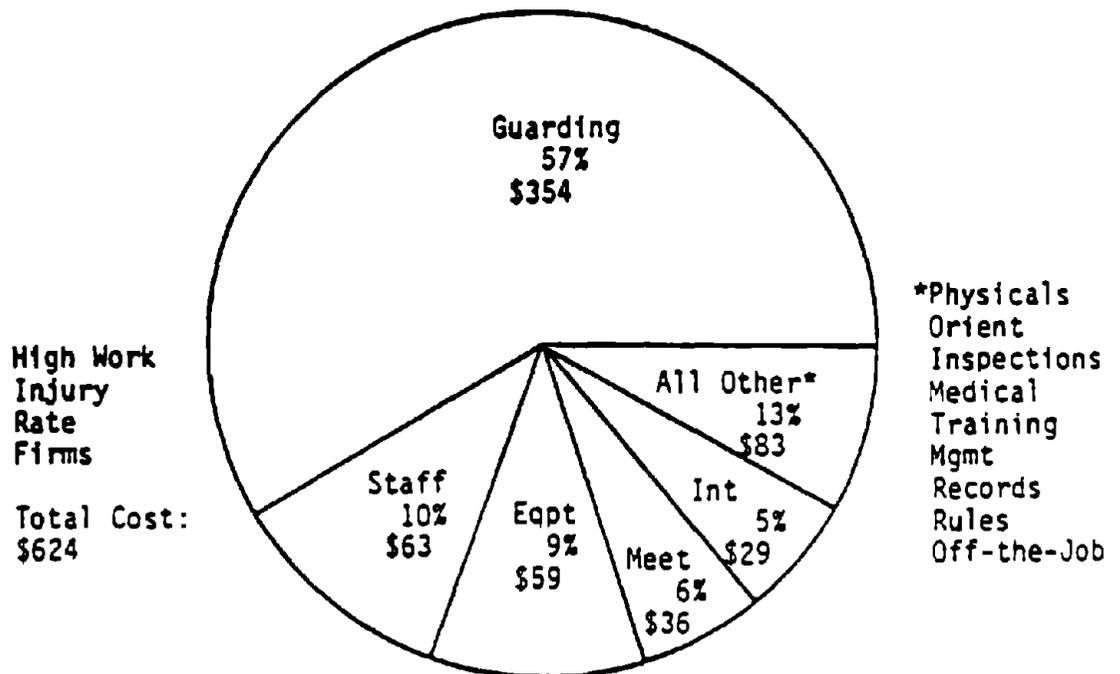
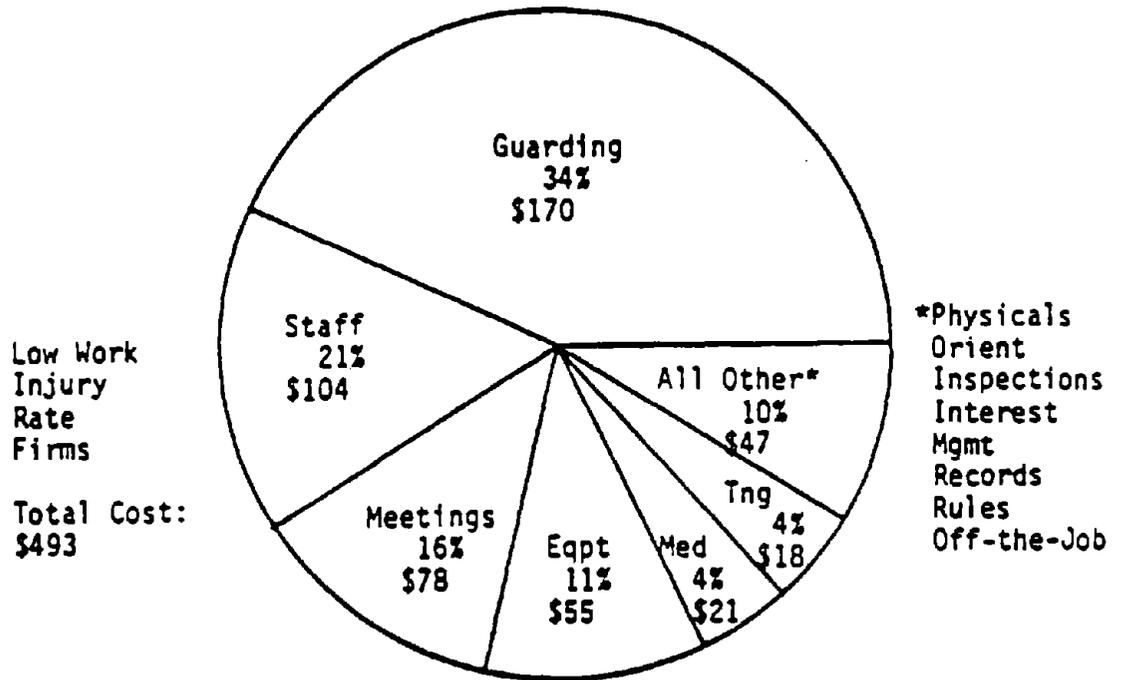


Figure 4

The Cost of Safety Activities by Percent of the Total Cost in Terms of Dollars Spent Per Employee for Large Texas Chemical Firm Respondents

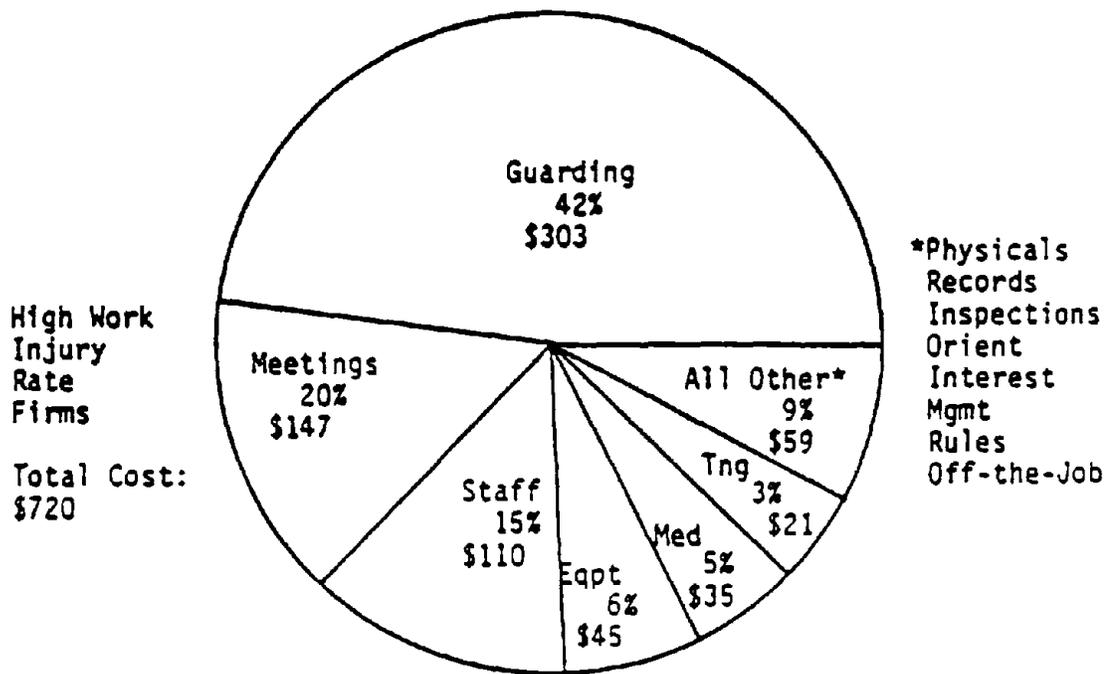
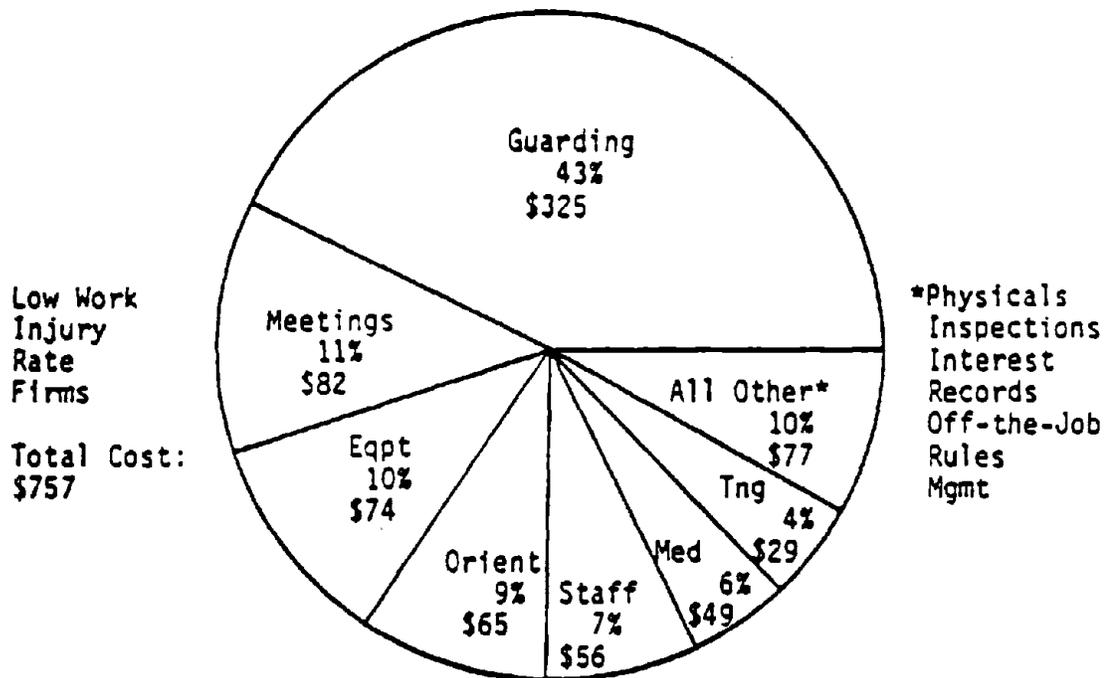


Figure 5

The Cost of Safety Activities by Percent of the Total Cost in Terms of Dollars Spent Per Employee for Small Texas Paper Product Firm Respondents

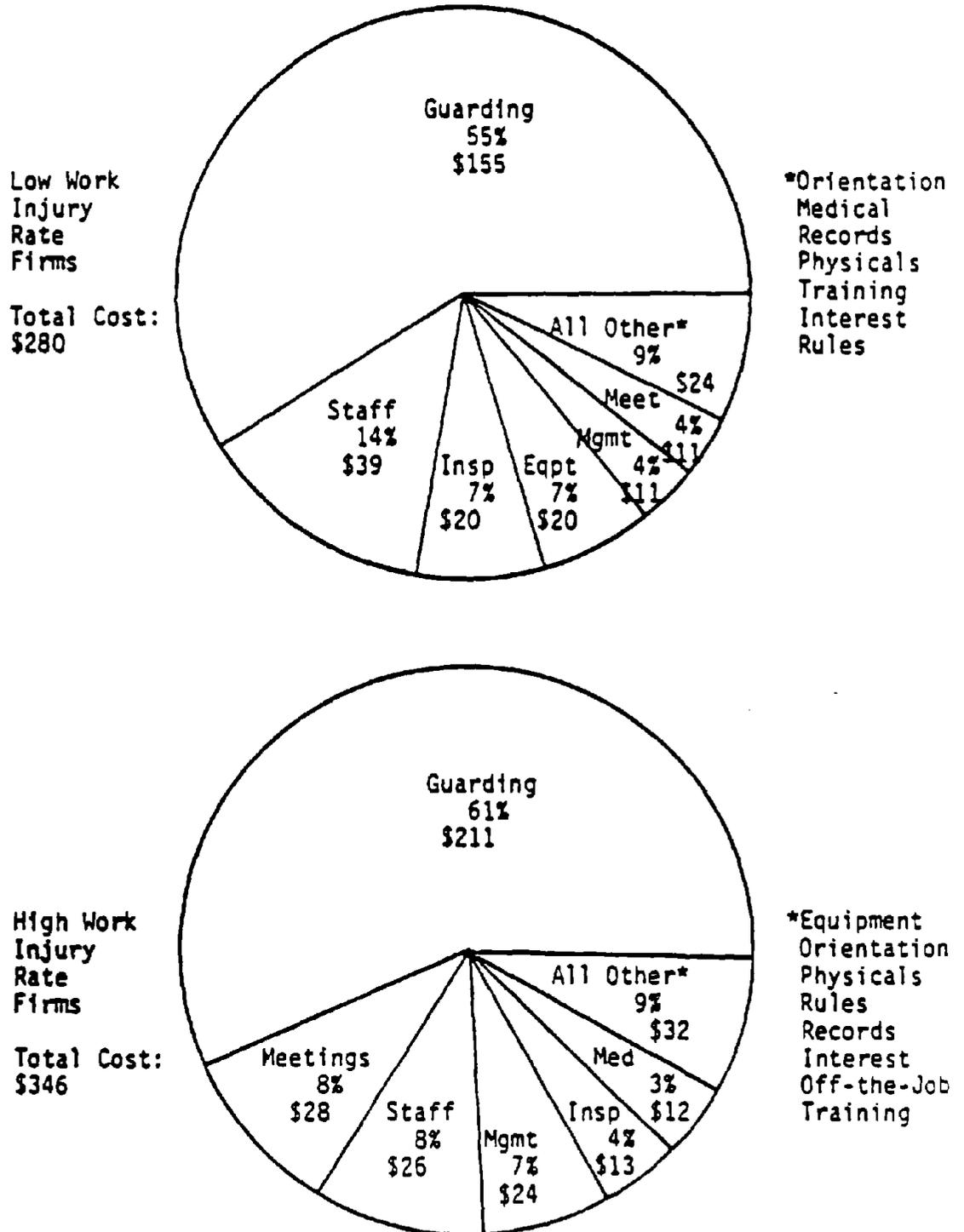


Figure 6

The Cost of Safety Activities by Percent of the Total Cost in Terms of Dollars Spent Per Employee for Medium-Sized Texas Paper Product Firm Respondents

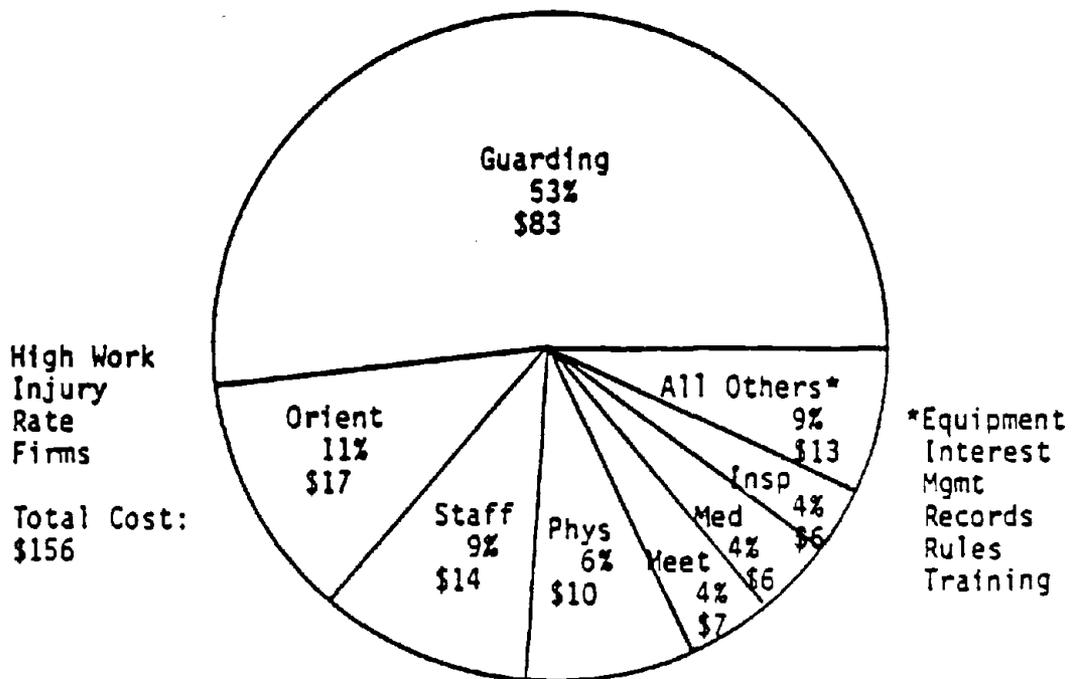
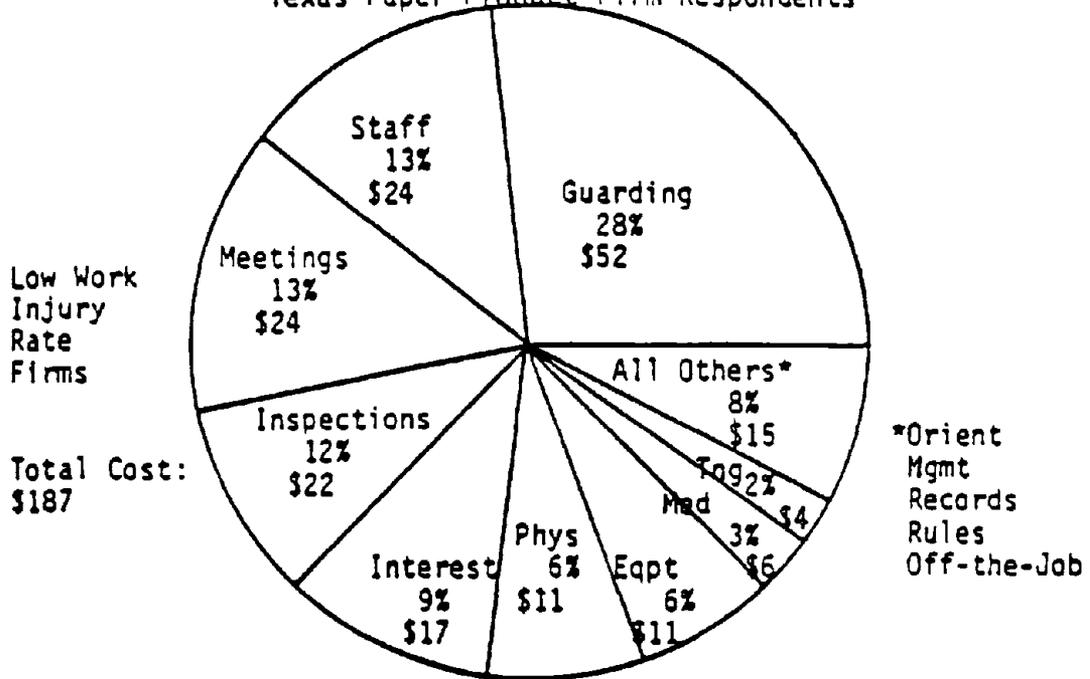


Figure 7

The Cost of Safety Activities by Percent of the Total Cost in Terms of Dollars Spent Per Employee for Large Texas Paper Product Firm Respondents

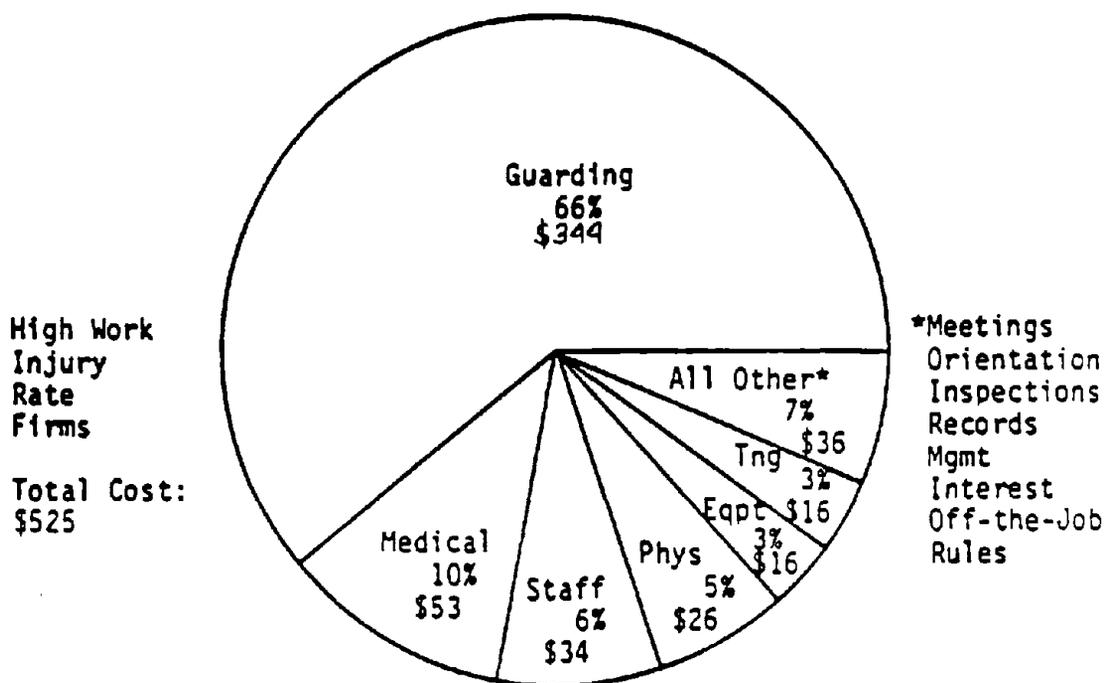
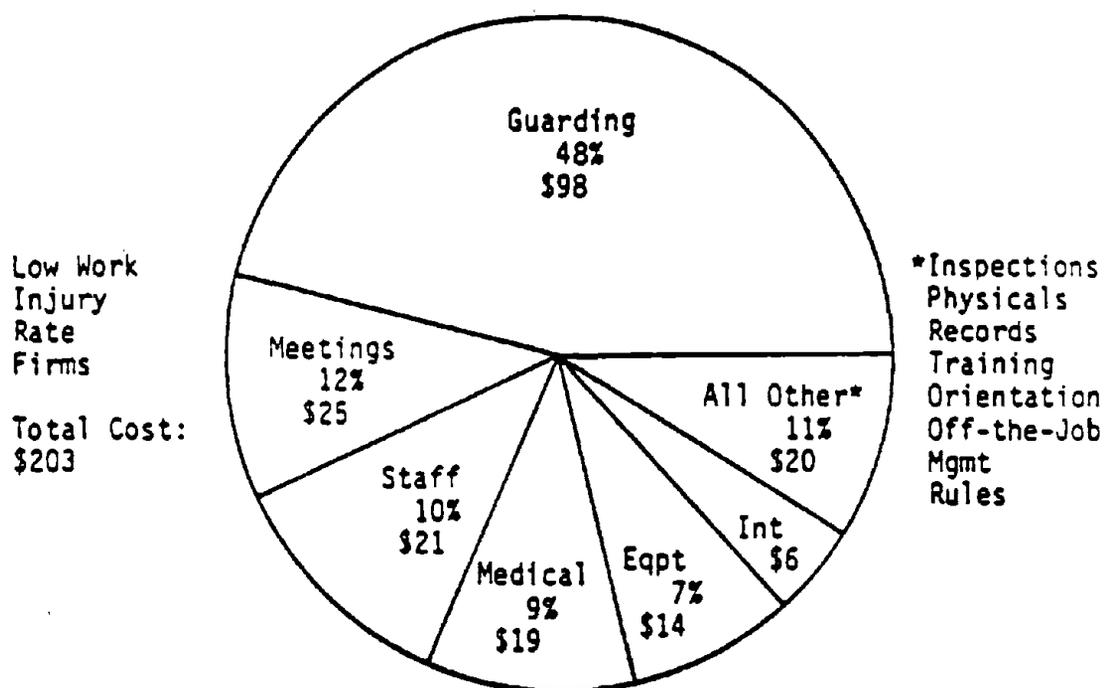


Figure 8

The Cost of Safety Activities by Percent of the Total Cost in Terms of Dollars Spent Per Employee for Small Texas Wood Product Firm Respondents

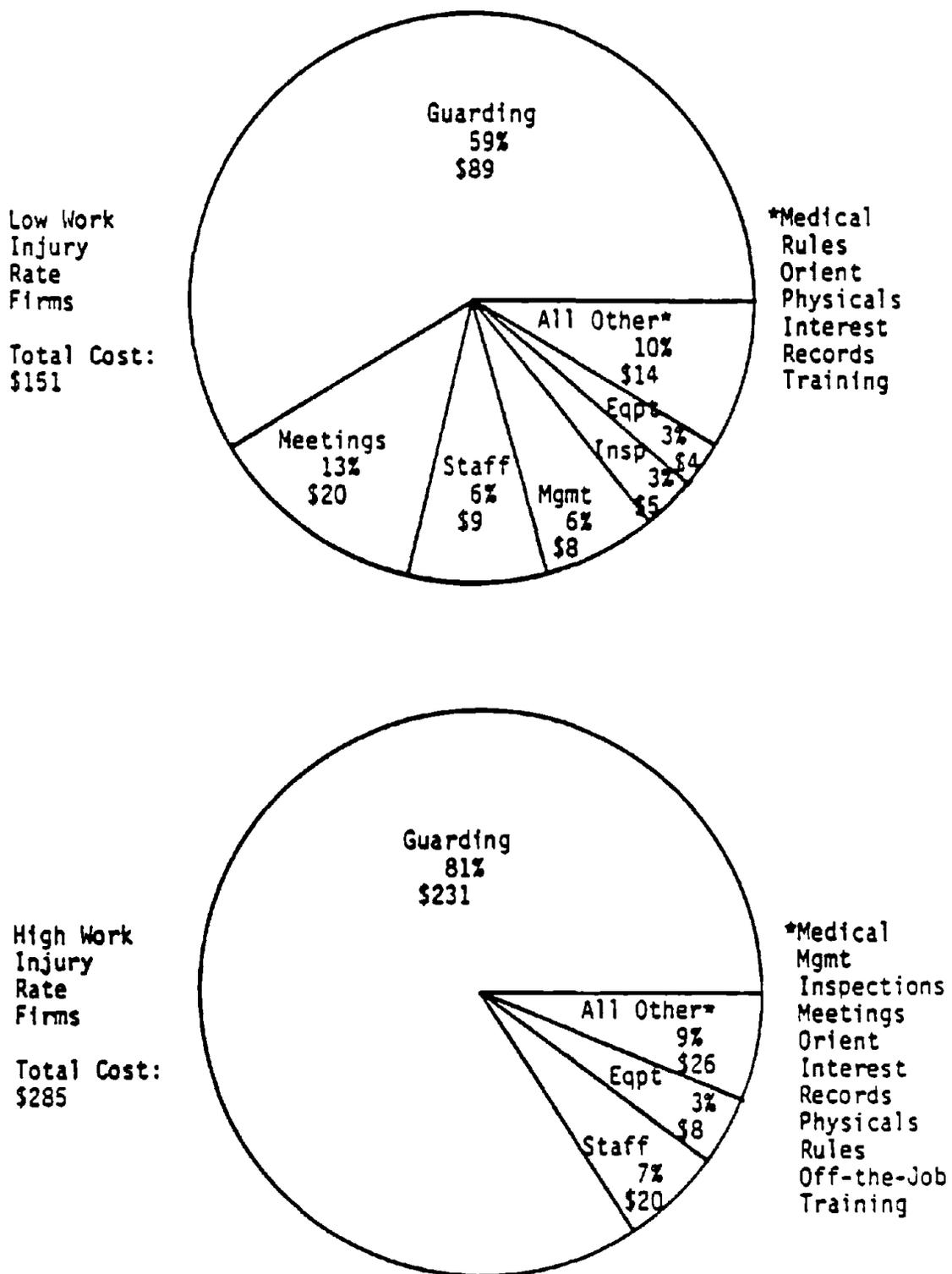


Figure 9

The Cost of Safety Activities by Percent of the Total Cost in Terms of Dollars Spent Per Employee for Medium-Sized Texas Wood Product Firm Respondents

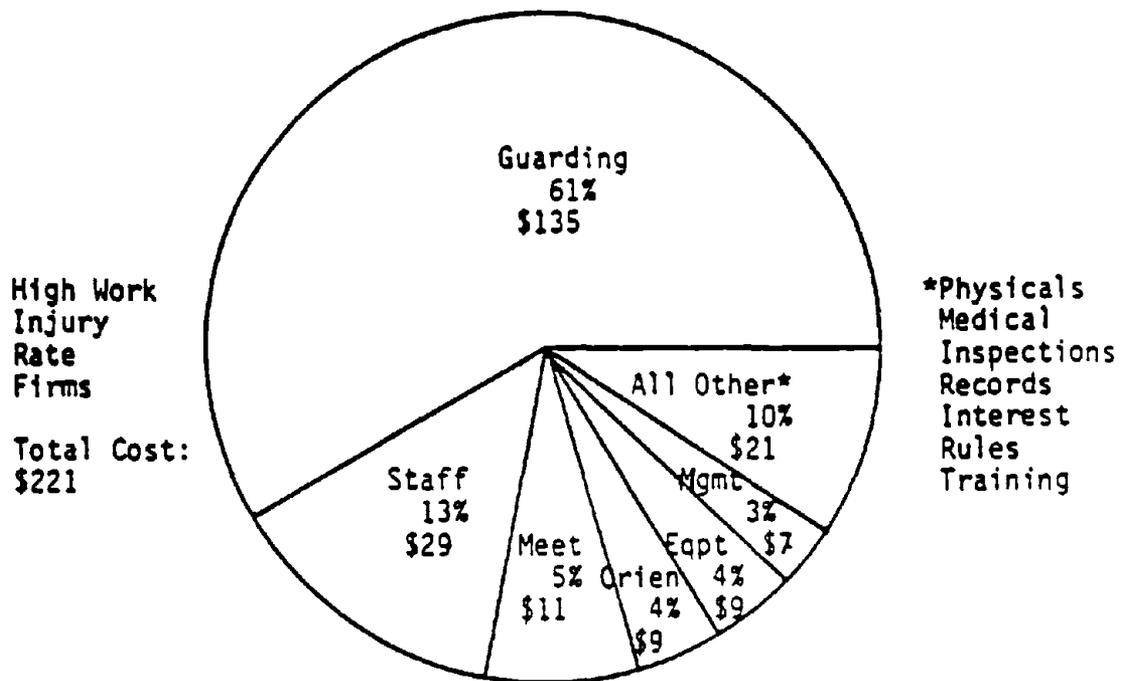
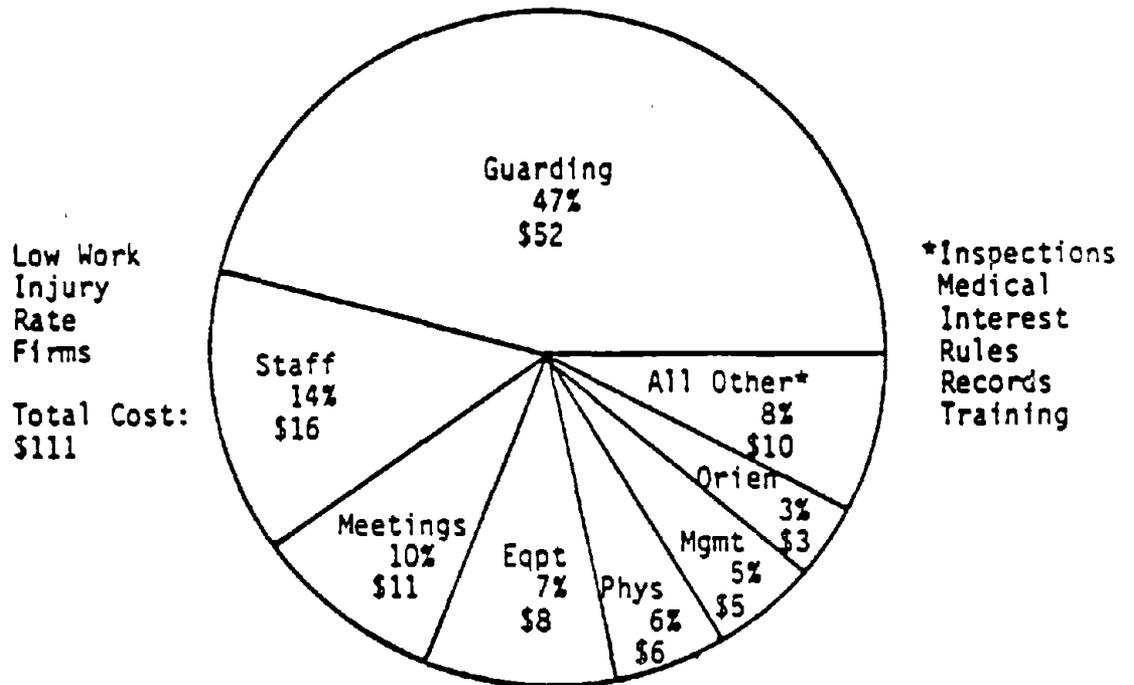
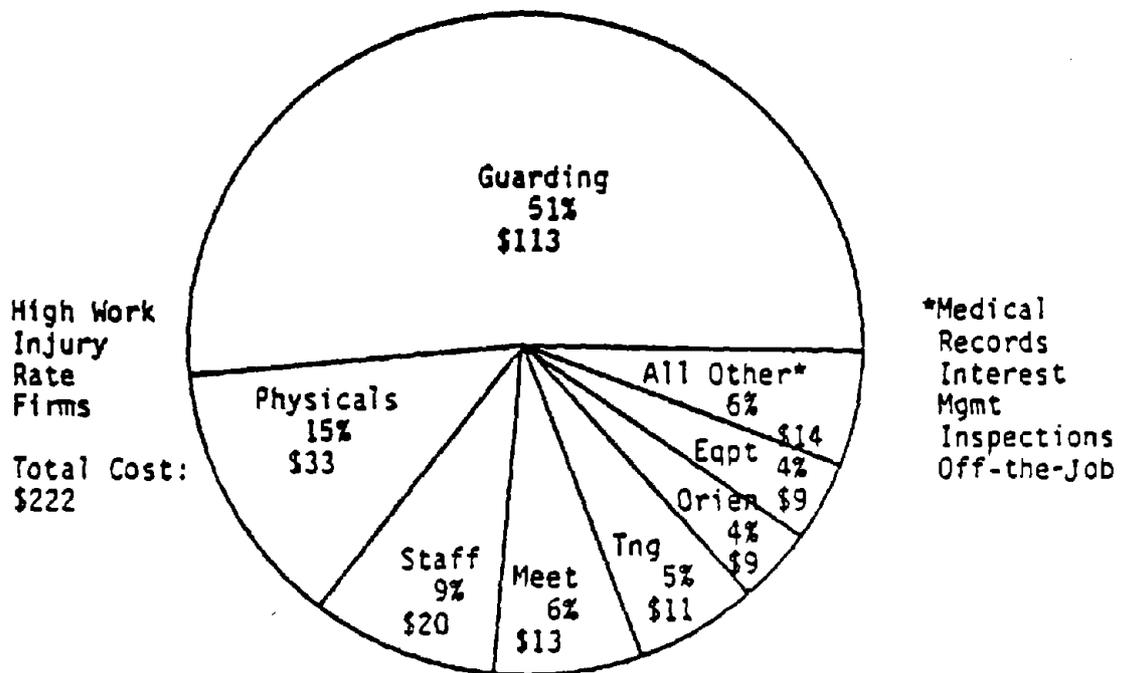
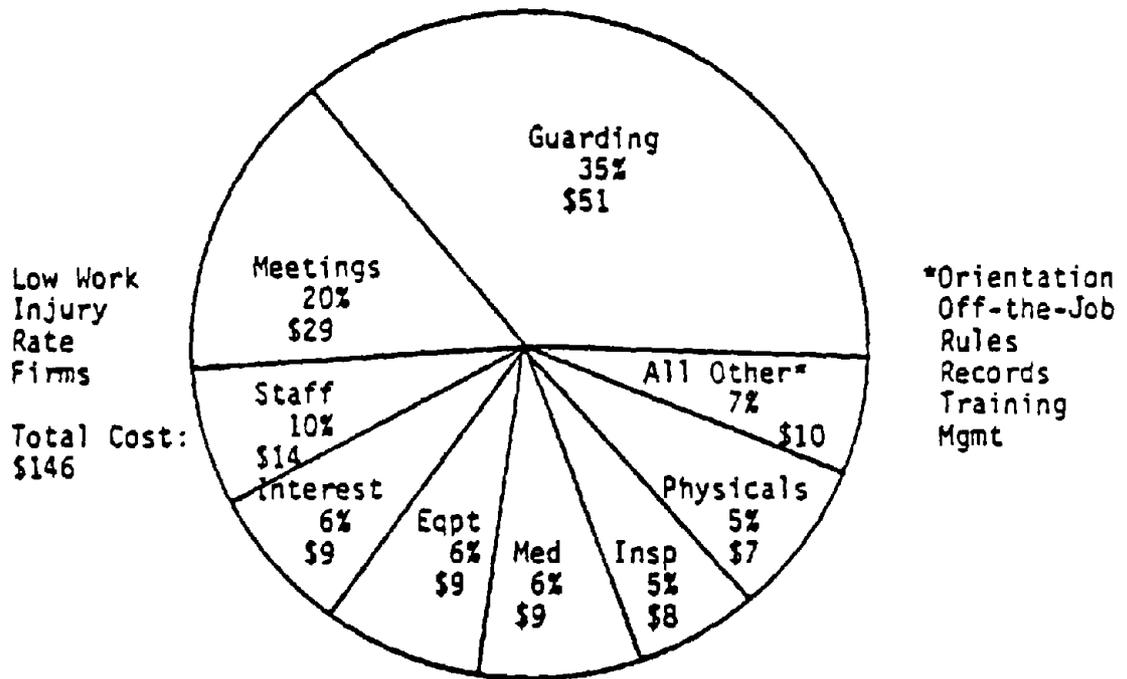


Figure 10

The Cost of Safety Activities by Percent of the Total Cost in Terms of Dollars Spent Per Employee for Large Texas Wood Product Firm Respondents



A surprising and important finding of this study can be noted by reviewing the data in these figures. In seven of the nine cells or firms of a specified size in an industry those firms with lower work injury frequency rates spent less on the average for their safety program activities than those firms of similar size and in the same industry which had poorer safety records. One possible explanation for this phenomenon is that safety performance is more dependent upon the correct mix of safety activities and upon the quality of such activities than upon the absolute amount of monies spent.

A detailed review of the occupational safety and health loss control activities and their monetary costs for Texas chemical, paper and wood product firm respondents has now been made. This information shows that there is a wide variation in both those occupational safety and health loss control activities which were reported and in the mix or combination of these activities. This variation occurs between firms of approximately the same size in the same industry and is more pronounced between firms of different sizes and in different industries.

Statistical analyses of the data can be made in order to obtain further information about these variations. However, before this analysis can be made information about the cost of losses first must be provided.

#### The Cost of Work Injuries and Illnesses

The monetary cost of work injuries and illnesses was calculated for each survey respondent and for each grouping of respondents by size and by lost time injury frequency rate within each industry grouping.

This total monetary cost of work injuries to firms was calculated by adding together the direct cost of work injuries or monies paid to injured employees, an estimate of the monies paid beyond the direct cost of work injuries to workmen's compensation insurance carriers in Texas and as estimate of the indirect or noninsured costs of work injuries.

The direct cost of work injuries or monies paid to injured employees or to their survivors in 1974 as detailed by the Texas Workmen's Compensation Act consisted of the payment of medical and hospital expenses, weekly indemnity which is an amount paid to injured employees during a portion of the time they are unable to work, lump sum payments to compensate for loss of a portion of the body or loss of use of a portion of the body and death benefits paid to survivors if an employee is killed at work. In the event of a work death the Texas Workmen's Compensation Act in 1974 paid two-thirds of the wages of the deceased up to \$63 a week to the surviving spouse for life or until remarriage and to children until age 18 or 25 if the children were full time students. In addition, the law provided \$500 for a burial allowance. Because no survey respondents provided an estimate of the insured cost of their fatalities and because a wider sample was desired, an estimate of this cost was obtained from the state of Texas. According to Mr. Edward Kasper, Director of Research, Workmen's Compensation Section, State Board of Insurance, State of Texas, the average amount of money set aside for fatal work injuries in Texas in 1973 was \$22,700. Therefore, this figure was used to estimate the cost of reported fatal work injuries or illnesses.

The greatest proportion of the direct cost of work injuries to firms consists of the cost of disabling or lost time work injuries and illnesses. These are work injuries in which the injured is unable to return to work on his next regularly scheduled shift according to American National Standards Institute Standard Z16.1, the Method of Recording and Measuring Work Injury Experience (2). In Texas, when an employee is so injured, the insurance carrier of the employer pays medical and hospital expenses and after a waiting period of seven days pays a weekly indemnity of two-thirds of the wages up to \$63 a week to the injured person. These costs of lost time work injuries were reported by 11 of the 56 chemical firm respondents, seven of the 38 paper and allied product firm respondents and by ten of 46 wood product respondents. The average cost of these work injuries was \$1910 and this figure was used to calculate the cost of reported disabling or lost time work injuries.

The third and last type of work injury or illness for which costs were calculated was work injuries requiring medical attention but not involving lost time as defined by the ANSI Standard Z16.1 (2). The average cost of these injuries based upon conversations with many survey respondents was estimated to be \$30.

The total direct cost of work injuries for each respondent was calculated to be the average number of fatalities, if any, occurring in 1972, 1973 and 1974 times \$22,700 per fatality plus the average number of lost time work injuries reported in 1972, 1973 and 1974 times \$1910 per such injury plus the average number of medical cases reported during 1972, 1973 and 1974 times \$30 per medical case. When the number of such occurrences was not reported by a firm for one or two of these years calculations were made based upon the information which was provided.

Next, an estimate of the monies paid beyond the direct cost of work injuries to Texas workmen's compensation insurance carriers was made. After reviewing the mechanics of calculating the workmen's compensation insurance premium for each survey and realizing that even if all calculations were made significant error might still occur, the author concluded that an estimate of the cost of workmen's compensation insurance premiums based upon the direct cost of work injuries and illnesses would provide information of sufficient accuracy for this study. Mr. Edward Kasper, Director of Research, Workmen's Compensation Section, Texas Board of Insurance, indicated that in 1973 the direct cost of work injuries was an estimated 56% of the cost of workmen's compensation insurance for Texas employers. Therefore, insurance costs were calculated for each survey respondent by multiplying the direct cost of work injuries times 1.79. Finally, estimates of the indirect or noninsured cost of work injuries were made. These noninsured costs, according to Rollin H. Simonds and John V. Grimaldi in Safety Management, consist of:

1. Wage cost of time lost by workers who were not injured.
2. The net cost to repair, replace or straighten up material or equipment that was damaged in an "accident."
3. Cost of wages paid for working time lost by injured workers other than workmen's compensation payments.

4. Extra cost due to overtime work necessitated by an accident.
5. Cost of wages paid supervisors while their time is required for activities necessitated by the "accident."
6. Wage cost due to decreased output of injured worker after return to work.
7. Cost of learning period of new worker.
8. Uninsured medical cost borne by the company.
9. Cost of time spent by higher supervision and clerical workers on investigations or in the processing of compensation application forms.
10. Miscellaneous unusual cost.<sup>1/</sup>

Estimates of these indirect, noninsured costs of work injuries were requested from survey respondents. However, no respondents to the mailed instrument and no respondents interviewed had this information. Therefore, following Simonds' procedures, these costs were estimated to be equal to the direct insured cost of work injuries (70).

The total cost of work injuries was calculated to be the sum of the direct costs plus an estimate of additional monies paid to workmen's compensation companies plus the estimated indirect noninsured cost of such injuries. The total cost of work injuries per employee is the total cost of work injuries divided by the total number of employees for each respondent.

Last, comparisons of work injury frequency rates to the total cost of work injuries were made for each respondent. This was done by means of a computer plot performed on the Texas A&M University computer by a Statistical Analysis System routine (4). The total cost of the work injuries of each respondent was compared to the total cost of the safety activities of the respondent by this procedure and a scatter diagram was produced for each of the nine cells. Each value plotted was identified as that of either a low injury frequency rate or a high injury frequency rate firm. A visual examination of these plots showed that the total cost of work injuries for all high injury frequency rate firms was higher than the costs for firms with low injury frequency rates. Therefore, in this study high injury frequency rate firms had relatively higher costs of work injuries and low injury rate firms had relatively lower costs.

These costs of work injuries can now be compared to the cost of occupational safety and health loss control activities in order to make estimates about the relative effectiveness of various loss control activities.

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<sup>1/</sup> R. H. Simonds and J. V. Grimaldi, Safety Management, Third Edition (Homewood, Ill.: Richard D. Irwin, 1975), p. 397, Ref. (70).

Comparison of the Cost of Occupational Safety  
and Health Loss Control Activities to the Cost  
of Work Injuries and Illnesses

Three general types of comparisons of the monetary cost of occupational safety and health loss control activities to the monetary cost of work injuries and illnesses have been made. First, graphic comparisons have been made so that relationships could be visualized. Second, multiple linear regressions were performed to calculate the effect of loss control activities, the independent variables, upon the dependent variable cost of work injuries. Third, combinations of selected independent variables were compared to the independent variable, cost of work injuries, by means of multiple linear regressions in order to provide some further information about relationships.

A bar graph providing a comparison of the average cost of safety activities per employee and of work injuries per employee for the chemical, paper and wood product industries is labeled Figure 11. This shows that generally there appears to be a relationship between monies expended by firms to prevent work injuries and illnesses and those injuries and illnesses which do occur.

Bar charts showing the cost of safety activities and work injuries in terms of dollars spent per employee by survey respondents are provided for the chemical, paper and wood products industries in Figures 12-14. These charts show that the average total monies spent to prevent losses per employee in 1974 was slightly more for seven of the nine groupings of firms by size for those firms which have high work injury frequency rates. Essentially these data indicate that differences in the cost of work injuries are not explained by different levels of expenditures for occupational safety and health loss control activities. In fact, firms with higher injury costs often spend more to prevent their work injuries than those firms which have lower costs of injuries. This is a surprising finding and one of some interest.

The second way that the cost of safety activities per employee was compared to the cost of work injuries per employee was by the calculation of a multiple linear regression. These calculations represent the heart of this study. The North Carolina State University Statistical Analysis System program was utilized and calculations were performed by the Texas A&M University computer system. The multiple linear regression procedure is a statistical technique used to explain or to partially explain the relationships between a number of independent variables and a dependent variable. The model assumes that a linear relationship between independent and dependent variables exists and that this relationship can be shown by the following equation:

$$Y = A + B_1X_1 + B_2X_2 + \dots + B_nX_n$$

In this equation Y represents the dependent variable and A represents a constant added to to the equation to represent the intercept if the equation were plotted in the conventional way.  $X_1, X_2 \dots X_n$  represent the various independent variables in the equation and  $B_1, B_2 \dots B_n$  are coefficients of the independent variables selected to maximize the value of the dependent variable. These coefficients or multipliers of the independent variables as used in this manner are called B values or regression coefficients. The probability that these B values or a value larger than these values could

Figure 11

The Cost of Safety Activities and of Work Injuries and Illnesses  
in Terms of Dollars Spent per Employee for Texas  
Chemical, Paper and Wood Product Firm Respondents

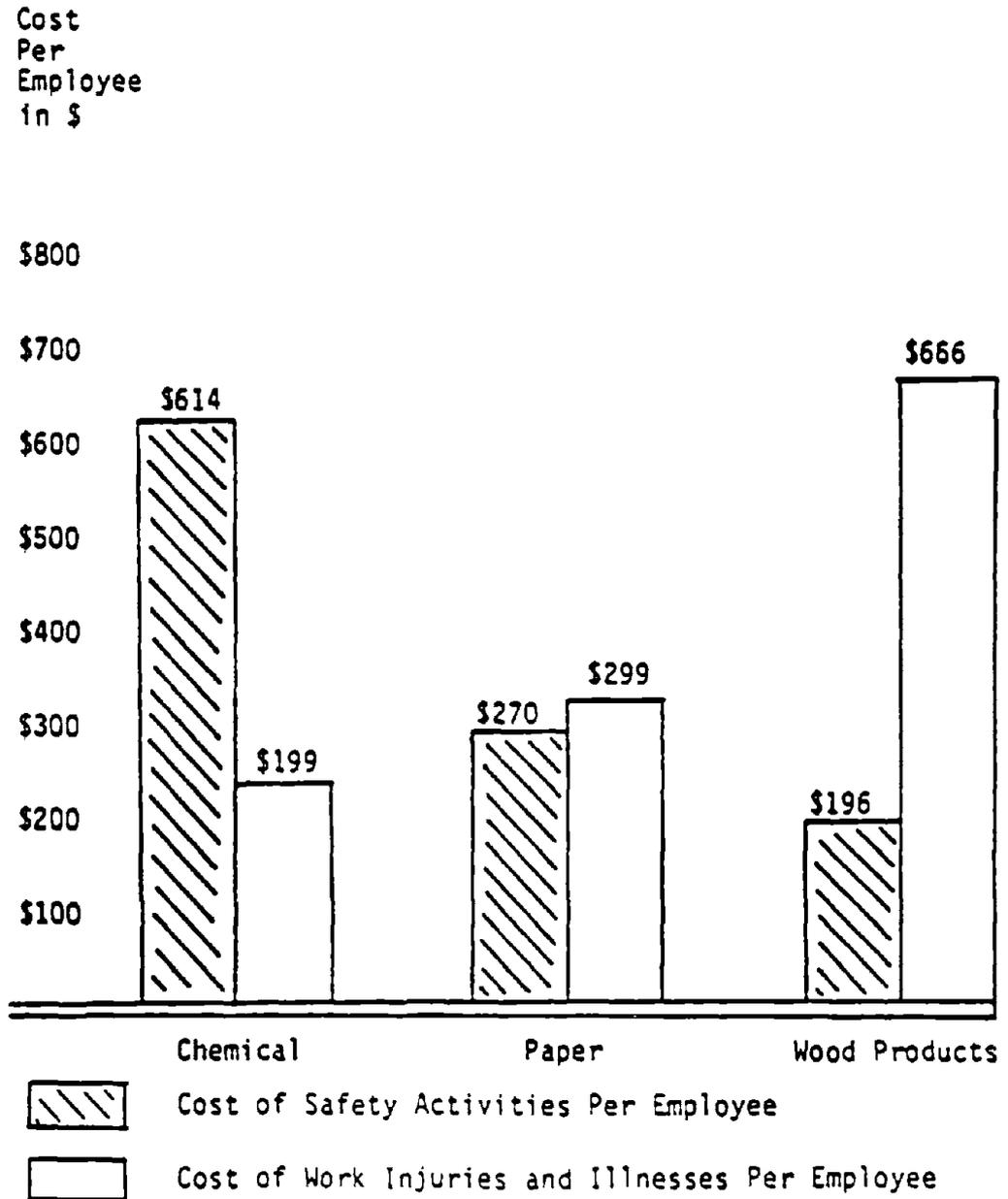


Figure 12

The Cost of Safety Activities and of Work Injuries and Illnesses  
 in Terms of Dollars Spent Per Employee for Texas  
 Chemical Firm Respondents

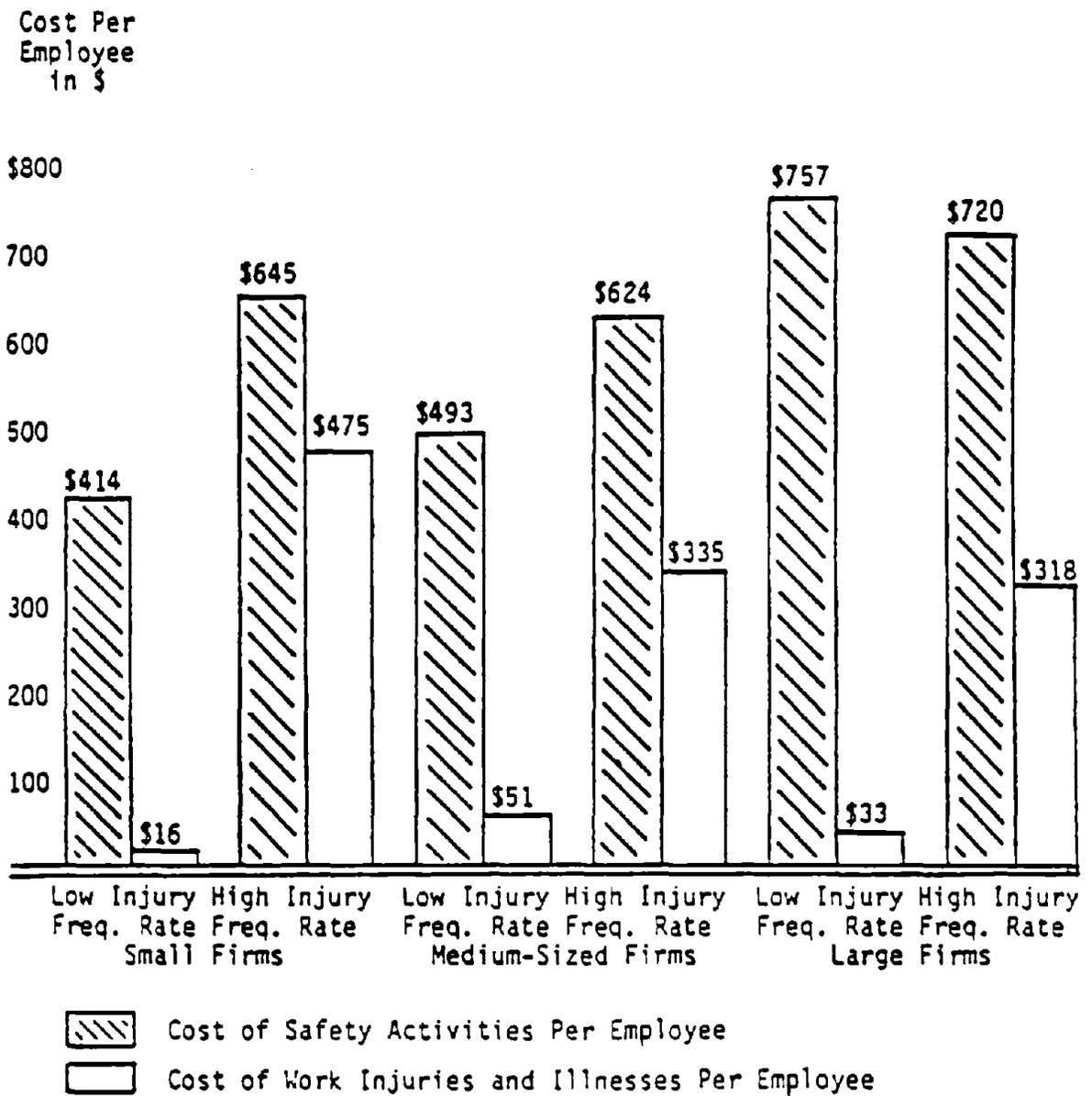


Figure 13

The Cost of Safety Activities and of Work Injuries and Illnesses  
 in Terms of Dollars Spent Per Employee for Texas  
 Paper Product Firm Respondents

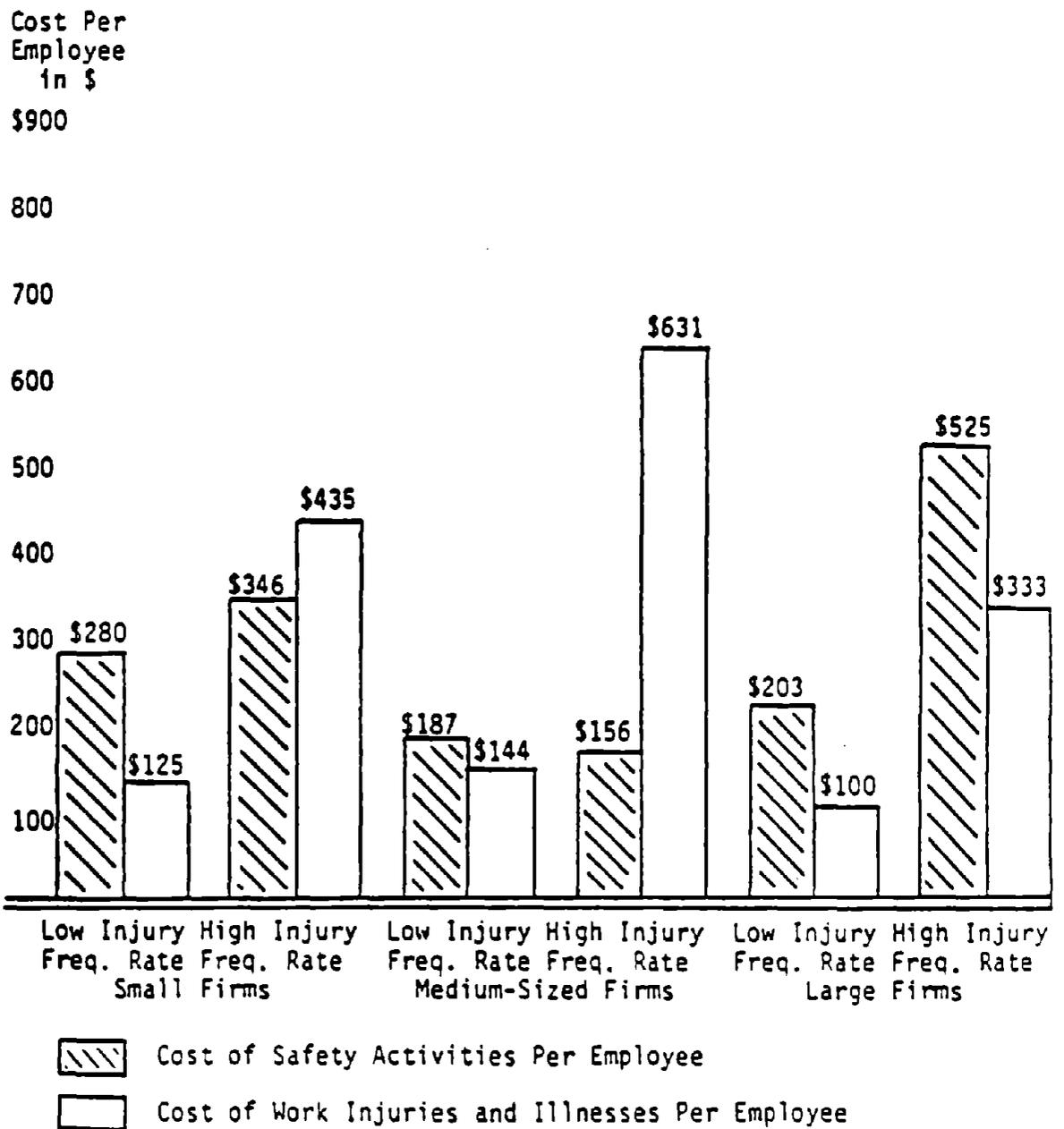
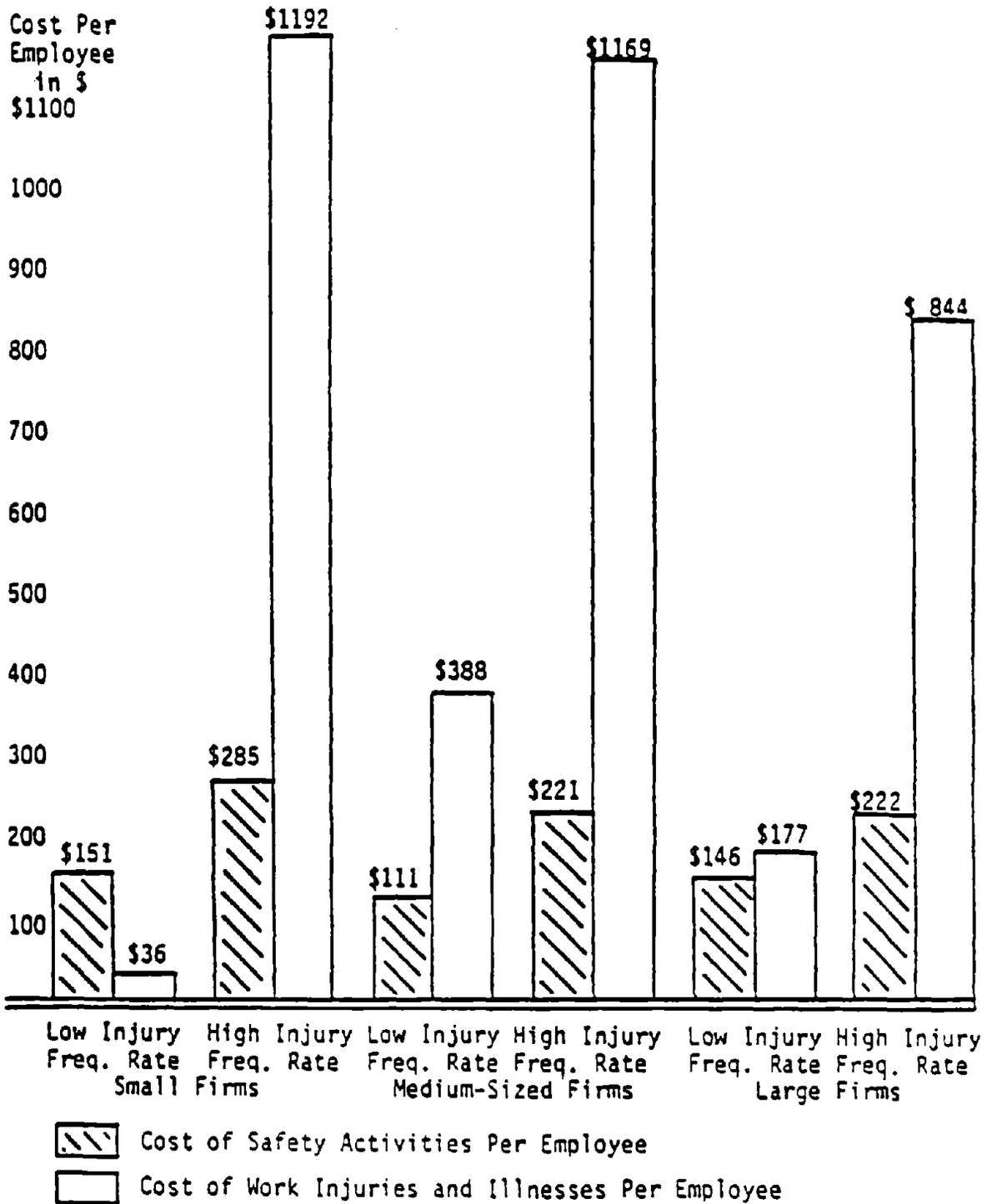


Figure 14

The Cost of Safety Activities and of Work Injuries and Illnesses  
 in Terms of Dollars Spent Per Employee for Texas  
 Wood Product Firm Respondents



have occurred if the true value actually were zero also can be computed for each of them. Last, an  $R^2$  can be calculated for each of the B values. This  $R^2$  represents the proportion of the variation in the dependent variable which is explained by the variation of an independent variable (54).

The James H. Goodnight maximum  $R^2$  improvement multiple linear regression model (4) was selected because it was judged to provide the greatest amount of information. This technique, "looks for the 'best' one variable model, the 'best' two variable model and so forth...in order to find the highest  $R^2$  statistic."<sup>2/</sup> In order to create a model with an additional variable, each variable in the model is compared to the variables which are not in the model and the variable is added which produces the largest increase in  $R^2$ . Variables are added in this manner to successively produce models with one, two, three...n numbers of variables in them (4).

Principal independent variables utilized in the model were the following types of expenses by employers:

- Management sometimes abbreviated to mgmt which is management activities regarding safety
- Staff which is the cost to employers of safety and health personnel
- Orientation or orient, the orientation of new employees
- Rules which are safety and health rules
- Interest defined as those activities to maintain employee interest in safety
- Meetings or meet which are safety meetings
- Inspections or insp which are safety inspections
- Equipment or eqpt, the cost to employers of personal protective equipment
- Guarding or guard which is the correction of unsafe physical conditions
- Physicals sometimes abbreviated phys which are physical examinations
- Medical or med which includes medical supplies, facilities and staff
- Off-the-Job or OTJ consisting of off-the-job safety activities
- Training or tng defined as training in safety and health
- Records or rec which are the cost of records maintained regarding safety and health

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<sup>2/</sup> A.J. Barr and J. H. Goodnight, A User's Guide to the Statistical Analysis System (Raleigh, N.C.: North Carolina State University, 1974), p. 128, Ref. (4)

Each of these variables was stated in dollar cost per employee during 1974. In addition, several other independent variables were considered in order to further explain the dependent variable, cost of work injuries. Two of these were used in the final analysis of data. In early attempts to increase the  $R^2$  or proportion of the variation in the dependent variable explained by the independent variables, the net profit of firms as a percent of sales, the age of the facility and the average hourly rate were included in the model. Because these variables are for the most part beyond the control of those people who are attempting to reduce the number of cost of work injuries at locations and because they explained a small proportion of the dependent variable they were not included in the final model. Generally this analysis indicated that there was little or no relationship between either the profit a firm made or the age of the facility and the cost of its work injuries. There seemed to be some relationship between the average hourly rate paid employees and the cost of work injuries in medium-sized and large chemical firms and in large paper product firms. Higher pay correlated with lower work injury costs in these cases to some degree. "Turnover" was added to the model to attempt to further explain the cause of the variation between firms with low work injury costs and those with high work injury costs. This figure was computed by dividing the number of new employees joining an organization in 1974 by the total number of employees in the organization and expressing this value as a percentage. It should more correctly be labeled accessions or additions to staff. It was found that this figure provided an additional explanation of the variation between firms by increasing the  $R^2$  from 2 to 19 points in five of the nine cells. However, in this study the variables utilized are the monetary cost of various factors to the firm expressed in terms of dollars per employee. The cost of accessions or additions to staff or of turnover to firms in terms of those activities designed to reduce work injuries and illnesses would be the cost of orienting and training new employees about safety and health and the cost of preemployment physical examinations given to new employees. Because these costs have already been included in the model adding them again would cause inaccuracies to occur. Therefore, the important question of the effect of turnover on the number and the costs of work injuries has not been directly addressed in this research.

Span of control or "span control" is the next variable which is discussed. Span of control is the average number of employees administered or supervised by a superior in an organization. In this study, because of the form of the data, span of control has been defined in a slightly different manner. Span of control has been defined in this study as a cost of supervision per employee. This value was calculated for each firm by multiplying the average annual income of first line supervisors times the number of supervisors in a firm and then dividing this figure by the number of employees in the organization. This variable was retained in the final model.

One last variable was included in the final model. It is the total number of employees in a firm or "employee number." The importance of this variable was understood when the research was designed and respondents were divided into large firms, those with more than 200 employees; medium-sized firms, those with between 50 and 199 employees; and small firms, those with less than 50 employees. The importance of this variable was better understood when it was found to explain a portion of the variation between high and low work injury costs within these classifications into firm sizes. Finally, the

importance of the size of the firms studied as measured by the total number of employees became clearer when it was found that a different mix of variables explained differences in work injury costs in small, medium-sized and large firms in each of the three industries studied.

Now that both the variables utilized in the final model and those variables not used have been described the results of the research can be presented. Tables 27-32 provide the results of selected information about the maximum  $R^2$  improvement multiple linear regression analysis of the effects of selected variables upon the cost of work injuries per employee for chemical industry respondents by size of firm. The first table in each series provides details about the selected iteration. This table shows the B value or unstandardized regression coefficients for each variable included in the model. It also provides the probability that the B value could have occurred if the true B value really was zero. It also provides the standard error of the B value or the standard deviation of the figure. Finally, these tables provide information showing additions to  $R^2$  caused by the entry of a variable into the model and the cumulative values of  $R^2$ . Because all of the variables except employee number are in the same units, B values can be used to provide estimates of the effect of the expenditure of \$1.00 per employee for a given variable upon the cost of work injuries per employee.

A second table in each of these series has been prepared in order to provide additional information about the variables. These tables list the initial B value or the B value for variables when they first entered the model. The tables also provide estimates of the probability that the listed B value or a larger value could have occurred if the true B value was zero. Last, these tables indicate the standard error or the standard deviation of each of the B values.

In a similar fashion, Tables 33 to 38 present information about the final analysis of data made by the maximum  $R^2$  improvement multiple linear regression analysis of the effect of selected variables on the cost of work injuries per employee for small, medium-sized and large Texas paper product firm respondents. Again B values or regression coefficients indicate the estimated relationship between the independent variables and the dependent variable. In clearest terms this value represents one approximation of the relative effect of the expenditure of \$1.00 for the activity described by the variable upon the cost of work injuries per employee in the particular grouping of firms.

Finally, similar information has been prepared for Texas wood product firm respondents. This material is provided in Tables 39-44. Once again the first table in a series provides information about the selected iteration which is the model in which the greatest explanation of data at satisfactory levels of probability occurs. The second table provides initial B values for each variable entering the model at any point for which a probability of approximately 0.25 or less occurred.

Because a large amount of information has been presented in Tables 27 to 44 these results have been further summarized. Table 45 provides the  $R^2$  value for the three classifications of firms by size for each of the three industries studied. In addition, this table provides similar information for analyses made of the data of all small, medium-sized and large respondents. These

TABLE 27

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear  
Regression Analysis of the Effect of Selected  
Variables Upon the Cost of Work Injuries per  
Employee for Small Texas Chemical Firm Respondents

| Variable     | B Values | Probability | Std.<br>Error B | Addition<br>to R <sup>2</sup> | Cumulative<br>R <sup>2</sup> |
|--------------|----------|-------------|-----------------|-------------------------------|------------------------------|
| Employee No. | - 5.84   | .21         | 4.42            | ---                           | ---                          |
| Staff        | 5.26     | .002        | 1.26            | .30                           | .30                          |
| Orientation  | 8.25     | .002        | 1.89            | .21                           | .51                          |
| Records      | -15.36   | .01         | 5.48            | .10                           | .61                          |
| Inspections  | - 6.35   | .02         | 2.43            | .09                           | .70                          |
| Rules        | - 5.69   | .08         | 2.96            | .08                           | .78                          |

Source: Analysis of data, chemicals, computer run #42, 6 variable model

TABLE 28

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis of the Effect of Selected Variables upon the Cost of Work Injuries per Employee in Terms of Initial B Values for Small Texas Chemical Firm Respondents

| Variable     | Initial B Value | Probability | Std. Error B |
|--------------|-----------------|-------------|--------------|
| Employee No. | - 3.06          | .59         | 5.55         |
| Management   | 2.75            | .25         | 2.25         |
| Staff        | 4.52            | .03         | 1.85         |
| Orientation  | 4.53            | .03         | 1.92         |
| Rules        | - 5.70          | .08         | 2.96         |
| Interest     | *               |             |              |
| Meetings     | *               |             |              |
| Inspections  | - 4.76          | .08         | 2.55         |
| Equipment    | 8.65            | .05         | 1.46         |
| Guarding     | - .14           | .33         | .13          |
| Physicals    | 41.61           | .001        | 6.28         |
| Medical      | *               |             |              |
| Off-the-Job  | -38.89          | .001        | 7.64         |
| Training     | - 7.33          | .15         | 3.67         |
| Records      | -11.66          | .09         | 6.52         |
| Span Control | *               |             |              |

\*Did not enter the model or entered it at a low probability

Source: Analysis of data, chemicals, computer run #42

TABLE 29

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression  
 Analysis of the Effect of Selected Variables upon  
 the Cost of Work Injuries per Employee for  
 Medium-Sized Texas Chemical Firm Respondents

| Variable     | B Values | Probability | Std.<br>Error B | Addition<br>to R <sup>2</sup> | Cumulative<br>R <sup>2</sup> |
|--------------|----------|-------------|-----------------|-------------------------------|------------------------------|
| Employee No. | - 1.41   | .03         | .59             | .18                           | .18                          |
| Meetings     | - 1.37   | .04         | .59             | .15                           | .33                          |
| Interest     | 5.19     | .01         | 1.78            | .13                           | .45                          |
| Management   | -22.53   | .06         | 10.76           | .11                           | .57                          |
| Training     | - 2.16   | .07         | 1.10            | .06                           | .63                          |
| Equipment    | - 2.02   | .001        | .65             | .03                           | .66                          |
| Orientation  | 9.71     | .001        | 2.91            | .03                           | .69                          |
| Span Control | - .08    | .21         | .06             | .03                           | .72                          |
| Off-the-Job  | -12.00   | .25         | 10.06           | .04                           | .76                          |

Source: Analysis of data, chemical, computer run #42, 9 variable model

TABLE 30

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis of the Effect of Selected Variables upon the Cost of Work Injuries per Employee in Terms of B Values for Medium-Sized Texas Chemical Firm Respondents

| Variable     | Initial B Value | Probability | Std. Error B |
|--------------|-----------------|-------------|--------------|
| Employee No. | - 1.11          | .07         | .59          |
| Management   | -22.53          | .05         | 10.76        |
| Staff        | *               |             |              |
| Orientation  | 3.81            | .15         | 2.54         |
| Rules        | -15.26          | .08         | 8.43         |
| Interest     | 5.19            | .01         | 1.78         |
| Meetings     | - 1.62          | .05         | .78          |
| Inspections  | *               |             |              |
| Equipment    | - 2.02          | .001        | .65          |
| Guarding     | *               |             |              |
| Physicals    | 5.93            | .23         | 2.86         |
| Medical      | - 2.67          | .22         | 2.12         |
| Off-the-Job  | -16.11          | .12         | 9.83         |
| Training     | - 2.03          | .17         | 1.45         |
| Records      | 20.70           | .10         | 12.09        |
| Span Control | - .08           | .21         | .06          |

\*Did not enter the model or entered it at a low probability

Source: Analysis of data, chemical, computer run #42

TABLE 31

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression  
 Analysis of the Effect of Selected Variables upon  
 the Cost of Work Injuries per Employee for  
 Large Texas Chemical Firm Respondents

| Variable     | B Value | Probability | Std.<br>Error B | Addition<br>to R <sup>2</sup> | Cumulative<br>R <sup>2</sup> |
|--------------|---------|-------------|-----------------|-------------------------------|------------------------------|
| Employee No. | - .29   | .04         | .12             | .13                           | .13                          |
| Medical      | - 3.48  | .01         | .88             | .16                           | .29                          |
| Span Control | - .37   | .01         | .09             | .19                           | .48                          |
| Staff        | 1.77    | .07         | .84             | .10                           | .58                          |
| Training     | - 2.44  | .06         | 1.12            | .10                           | .68                          |
| Records      | 3.97    | .23         | 3.12            | .04                           | .72                          |
| Guarding     | .28     | .08         | .14             | .04                           | .76                          |
| Orientation  | 1.99    | .08         | .99             | .04                           | .80                          |
| Off-the-Job  | -22.99  | .13         | 13.58           | .03                           | .83                          |

Source: Analysis of data, chemicals, computer run #42, 9 variable model

TABLE 32

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear  
Regression Analysis of the Effect of Selected  
Variables upon the Cost of Work Injuries per  
Employee in Terms of Initial B Values for  
Large Texas Chemical Firm Respondents

| Variable     | Initial<br>B Value | Probability | Std.<br>Error B |
|--------------|--------------------|-------------|-----------------|
| Employee No. | - .26              | .06         | .13             |
| Management   | 115.27             | .03         | 45.86           |
| Staff        | 1.70               | .08         | .92             |
| Orientation  | 1.99               | .07         | 1.02            |
| Rules        | *                  |             |                 |
| Interest     | 20.50              | .02         | 7.00            |
| Meetings     | *                  |             |                 |
| Inspections  | - 2.08             | .16         | 1.32            |
| Equipment    | *                  |             |                 |
| Guarding     | .14                | .30         | .13             |
| Physicals    | - 4.01             | .24         | 3.20            |
| Medical      | - 2.01             | .08         | 1.11            |
| Off-the-Job  | - 26.06            | .08         | 13.82           |
| Training     | - 1.94             | .08         | 1.05            |
| Records      | 4.60               | .20         | 3.38            |
| Span Control | - .20              | .03         | .09             |

\*Did not enter the model or entered it at a low probability

Source: Analysis of data, chemical, computer run #42

TABLE 33

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression  
 Analysis of the Effect of Selected Variables upon  
 the Cost of Work Injuries per Employee for  
 Small Texas Paper Product Firm Respondents

| Variable     | B Value | Probability | Std.<br>Error B | Addition<br>to R <sup>2</sup> | Cumulative<br>R <sup>2</sup> |
|--------------|---------|-------------|-----------------|-------------------------------|------------------------------|
| Employee No. | 13.94   | .01         | 3.10            | .01                           | .01                          |
| Guarding     | .99     | .002        | .11             | .32                           | .33                          |
| Records      | 246.33  | .002        | 30.48           | .27                           | .60                          |
| Off-the-Job  | -387.69 | .004        | 56.26           | .16                           | .76                          |
| Physicals    | - 36.80 | .004        | 5.83            | .11                           | .87                          |
| Inspections  | 4.57    | .03         | 1.41            | .05                           | .92                          |
| Staff        | - 3.08  | .10         | 1.46            | .04                           | .96                          |

Source: Analysis of data, paper, computer run #29, 7 variable model

TABLE 34

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis of the Effect of Selected Variables upon the Cost of Work Injuries per Employee in Terms of Initial B Values for Small Texas Paper Firm Respondents

| Variable     | Initial<br>B Value | Probability | Std.<br>Error B |
|--------------|--------------------|-------------|-----------------|
| Employee No. | - 4.41             | .53         | 5.80            |
| Management   | 9.50               | .02         | 3.35            |
| Staff        | - 3.08             | .10         | 1.46            |
| Orientation  | - 5.03             | .28         | 3.83            |
| Rules        | *                  |             |                 |
| Interest     | *                  |             |                 |
| Meetings     | 4.73               | .06         | 2.22            |
| Inspections  | 2.37               | .11         | 1.23            |
| Equipment    | *                  |             |                 |
| Guarding     | .25                | .22         | .18             |
| Physicals    | - 33.13            | .01         | 7.23            |
| Medical      | 32.87              | .06         | 8.57            |
| Off-the-Job  | -357.90            | .004        | 70.71           |
| Training     | *                  |             |                 |
| Records      | 214.64             | .002        | 34.88           |
| Span Control | - .29              | .06         | .13             |

\*Did not enter the model or entered it at a low probability

Source: Analysis of data, paper, computer run #29

TABLE 35

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression  
 Analysis of the Effect of Selected Variables upon  
 the Cost of Work Injuries per Employee for  
 Medium-Sized Texas Paper Firm Respondents

| Variable     | B Value | Probability | Std.<br>Error B | Addition<br>to R <sup>2</sup> | Cumulative<br>R <sup>2</sup> |
|--------------|---------|-------------|-----------------|-------------------------------|------------------------------|
| Employee No. | 3.81    | .29         | 3.35            | .25                           | .25                          |
| Rules        | 84.09   | .04         | 34.99           | .18                           | .43                          |
| Guarding     | 3.23    | .01         | 1.00            | .09                           | .52                          |
| Training     | -133.92 | .02         | 43.82           | .07                           | .59                          |
| Management   | 156.45  | .02         | 55.91           | .07                           | .66                          |
| Interest     | - 11.91 | .06         | 5.46            | .06                           | .72                          |
| Orientation  | - 6.39  | .07         | 2.98            | .09                           | .83                          |

Source: Analysis of data, paper, computer run #29, 7 variable model

TABLE 36

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis of the Effect of Selected Variables upon the Cost of Work Injuries per Employee in Terms of Initial B Values for Medium-Sized Texas Paper Firm Respondents

| Variable     | Initial B Value | Probability | Std. Error B |
|--------------|-----------------|-------------|--------------|
| Employee No. | - 6.13          | .05         | 2.89         |
| Management   | 77.18           | .20         | 56.97        |
| Staff        | *               |             |              |
| Orientation  | - 6.39          | .07         | 2.98         |
| Rules        | 82.04           | .07         | 41.36        |
| Interest     | - 8.43          | .21         | 6.28         |
| Meetings     | *               |             |              |
| Inspections  | 5.03            | .002        | .74          |
| Equipment    | -15.98          | .04         | 5.99         |
| Guarding     | 1.60            | .17         | 1.10         |
| Physicals    | 8.59            | .18         | 5.68         |
| Medical      | -96.57          | .02         | 28.12        |
| Off-the-Job  | *               |             |              |
| Training     | -45.75          | .22         | 34.88        |
| Records      | *               |             |              |
| Span Control | - .68           | .008        | .15          |

\*Did not enter the model or entered it at a low probability

Source: Analysis of data, paper, computer run #29

TABLE 37

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression  
 Analysis of the Effect of Selected Variables upon  
 the Cost of Work Injuries per Employee for  
 Large Texas Paper Firm Respondents

| Variable                  | B Value | Probability | Std.<br>Error B | Addition<br>to R <sup>2</sup> | Cumulative<br>R <sup>2</sup> |
|---------------------------|---------|-------------|-----------------|-------------------------------|------------------------------|
| Employee No.              | - .01   | .79         | .03             | .15                           | .15                          |
| Off-the-Job<br>Management | - 29.58 | .01         | 7.55            | .31                           | .46                          |
| Span Control              | 135.83  | .001        | 17.92           | .21                           | .67                          |
| Interest                  | - .28   | .002        | .04             | .15                           | .82                          |
|                           | - 9.54  | .05         | 3.88            | .14                           | .96                          |

Source: Analysis of data, paper, computer run #29, 5 variable model

TABLE 38

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis of the Effect of Selected Variables upon the Cost of Work Injuries per Employee in Terms of Initial B Values for Large Texas Paper Firm Respondents

| Variable     | Initial<br>B Value | Probability | Std.<br>Error B |
|--------------|--------------------|-------------|-----------------|
| Employee No. | - .04              | .63         | .09             |
| Management   | 100.38             | .004        | 12.19           |
| Staff        | 5.63               | .02         | 1.80            |
| Orientation  | 8.85               | .03         | 2.35            |
| Rules        | *                  |             |                 |
| Interest     | - 9.54             | .05         | 3.88            |
| Meetings     | - 6.18             | .06         | 2.91            |
| Inspections  | - 7.92             | .06         | 2.99            |
| Equipment    | *                  |             |                 |
| Guarding     | *                  |             |                 |
| Physicals    | *                  |             |                 |
| Medical      | *                  |             |                 |
| Off-the-Job  | - 35.20            | .01         | 7.55            |
| Training     | - 1.79             | .02         | .27             |
| Records      | - 11.18            | .09         | 4.52            |
| Span Control | - .30              | .003        | .06             |

\*Did not enter the model or entered it at a low probability

Source: Analysis of data, paper, computer run #29

TABLE 39

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression  
 Analysis of the Effects of Selected Variables upon  
 the Cost of Work Injuries per Employee for  
 Small Texas Wood Product Firm Respondents

| Variable     | B Value | Probability | Std.<br>Error B | Addition<br>to R <sup>2</sup> | Cumulative<br>R <sup>2</sup> |
|--------------|---------|-------------|-----------------|-------------------------------|------------------------------|
| Employee No. | - 25.09 | .002        | 5.46            | .02                           | .02                          |
| Span Control | - .63   | .03         | .27             | .17                           | .19                          |
| Meetings     | - 27.93 | .001        | 3.98            | .16                           | .35                          |
| Physicals    | 73.04   | .003        | 17.53           | .25                           | .60                          |
| Interest     | 190.18  | .001        | 31.77           | .11                           | .71                          |
| Orientation  | -137.97 | .001        | 27.59           | .12                           | .83                          |
| Training     | -100.19 | .01         | 26.31           | .11                           | .94                          |

Source: Analysis of data, wood products, computer run #43, 7 variable model

TABLE 40

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis of the Effect of Selected Variables upon the Cost of Work Injuries per Employee in Terms of Initial B Values for Small Texas Wood Product Firm Respondents

| Variable     | Initial<br>B Value | Probability | Std.<br>Error B |
|--------------|--------------------|-------------|-----------------|
| Employee No. | - 5.44             | .67         | 12.78           |
| Management   | - 5.56             | .01         | 1.66            |
| Staff        | *                  |             |                 |
| Orientation  | -106.45            | .03         | 41.61           |
| Rules        | 11.71              | .16         | 6.82            |
| Interest     | 104.68             | .07         | 52.58           |
| Meetings     | - 12.12            | .11         | 7.10            |
| Inspections  | *                  |             |                 |
| Equipment    | 32.98              | .008        | 8.97            |
| Guarding     | *                  |             |                 |
| Physicals    | 98.26              | .02         | 37.61           |
| Medical      | *                  |             |                 |
| Off-the-Job  | *                  |             |                 |
| Training     | -100.19            | .005        | 26.31           |
| Records      | *                  |             |                 |
| Span Control | - .51              | .06         | .26             |

\*Did not enter the model or entered it at a low probability

Source: Analysis of data, wood products, computer run #43

TABLE 41

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression  
 Analysis of the Effects of Selected Variables upon  
 the Cost of Work Injuries per Employee for  
 Medium-Sized Texas Wood Product Firm Respondents

| Variable     | B Value | Probability | Std.<br>Error B | Addition<br>to R <sup>2</sup> | Cumulative<br>R <sup>2</sup> |
|--------------|---------|-------------|-----------------|-------------------------------|------------------------------|
| Employee No. | - 2.29  | .62         | 4.48            | .32                           | .32                          |
| Orientation  | 78.50   | .001        | 4.48            | .50                           | .82                          |
| Physicals    | 145.81  | .001        | 27.10           | .09                           | .91                          |
| Rules        | -994.75 | .001        | 173.14          | .03                           | .94                          |
| Records      | 266.83  | .001        | 45.37           | .03                           | .97                          |
| Training     | -343.53 | .002        | 74.31           | .01                           | .98                          |
| Management   | - 83.80 | .02         | 28.71           | .01                           | .99                          |

Source: Analysis of data, wood products, computer run #46, 7 variable model

TABLE 42

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis of the Effect of Selected Variables upon the Cost of Work Injuries per Employee in Terms of Initial B Values for Medium-Sized Texas Wood Product Firm Respondents

| Variable     | Initial<br>B Value | Probability | Std.<br>Error B |
|--------------|--------------------|-------------|-----------------|
| Employee No. | - 12.38            | .05         | 5.97            |
| Management   | - 83.80            | .02         | 28.71           |
| Staff        | - 12.10            | .02         | 4.31            |
| Orientation  | 59.28              | .001        | 10.17           |
| Rules        | -726.82            | .002        | 173.14          |
| Interest     | - 11.11            | .32         | .43             |
| Meetings     | 9.06               | .02         | 2.81            |
| Inspections  | *                  |             |                 |
| Equipment    | *                  |             |                 |
| Guarding     | .55                | .28         | .44             |
| Physicals    | 78.81              | .01         | 25.56           |
| Medical      | - 17.95            | .42         | 17.64           |
| Off-the-Job  | *                  |             |                 |
| Training     | -209.79            | .09         | 111.43          |
| Records      | 93.36              | .07         | 45.19           |
| Span Control | *                  |             |                 |

\*Did not enter the model or entered it at a low probability

Source: Analysis of data, wood products, computer run #46

TABLE 43

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression  
 Analysis of the Effect of Selected Variables upon  
 the Cost of Work Injuries per Employee for  
 Large Texas Wood Product Firm Respondents

| Variable     | B Value | Probability | Std.<br>Error B | Addition<br>to R <sup>2</sup> | Cumulative<br>R <sup>2</sup> |
|--------------|---------|-------------|-----------------|-------------------------------|------------------------------|
| Employee No. | - .07   | .19         | .05             | .12                           | .12                          |
| Physicals    | 6.62    | .001        | .49             | .25                           | .37                          |
| Span Control | - .81   | .001        | .06             | .23                           | .60                          |
| Medical      | - 37.20 | .001        | 3.82            | .23                           | .83                          |
| Staff        | 10.57   | .001        | 1.36            | .16                           | .99                          |

Source: Analysis of data, wood products, computer run #46, 5 variable model

TABLE 44

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis of the Effect of Selected Variables upon the Cost of Work Injuries per Employee in Terms of Initial B Values for Large Texas Wood Product Firm Respondents

| Variable     | Initial<br>B Value | Probability | Std.<br>Error B |
|--------------|--------------------|-------------|-----------------|
| Employee No. | - .14              | .56         | .23             |
| Management   | 145.03             | .005        | 27.51           |
| Staff        | 10.57              | .001        | 1.36            |
| Orientation  | 6.64               | .003        | .92             |
| Rules        | 133.11             | .01         | 2.49            |
| Interest     | - 14.23            | .15         | 8.70            |
| Meetings     | 2.63               | .001        | .23             |
| Inspections  | *                  |             |                 |
| Equipment    | 31.04              | .004        | 4.86            |
| Guarding     | 3.36               | .07         | 1.57            |
| Physicals    | 6.62               | .001        | .49             |
| Medical      | - 37.20            | .001        | 3.82            |
| Off-the-Job  | *                  |             |                 |
| Training     | 12.23              | .01         | .17             |
| Records      | - 24.33            | .06         | 6.67            |
| Span Control | - .81              | .001        | .06             |

\*Did not enter the model or entered it at a low probability

Source: Analysis of data, wood products, computer run #46

TABLE 45

Comparison of  $R^2$  Values and Variables for the Selected Iteration of the Maximum  $R^2$  Improvement Multiple Linear Regression Analysis of the Effect of Selected Variables upon the Cost of Work Injuries per Employee for Texas Chemical, Paper and Wood Product Firm Respondents

| Industry      | Size of Firm |                     |               |                     |              |                     |
|---------------|--------------|---------------------|---------------|---------------------|--------------|---------------------|
|               | <u>Small</u> |                     | <u>Medium</u> |                     | <u>Large</u> |                     |
|               | $R^2$        | Number of Variables | $R^2$         | Number of Variables | $R^2$        | Number of Variables |
| Chemical      | .78          | 6                   | .78           | 9                   | .83          | 9                   |
| Paper         | .96          | 7                   | .83           | 7                   | .96          | 5                   |
| Wood Products | .94          | 7                   | .99           | 7                   | .99          | 5                   |
| All           | .05          | 3                   | .28           | 4                   | .64          | 6                   |

Source: Analysis of data, chemical run #42, paper run #29, wood products run #43 and #46

additional multiple linear regressions indicated that some similarity between the activities of large firms existed but that there was little similarity between the activities of medium-sized firms and essentially no similarity when small chemical, paper and wood product firms were compared. Similarly, although it is not shown in Table 45, relatively low  $R^2$  values occurred when data from all firms in an industry were compared to the costs of work injuries by firm. In the chemical industry the  $R^2$  value was .22 in a five variable model. In the paper industry the  $R^2$  was .26 in a four variable model. And in the wood product industry the  $R^2$  was .18 in a five variable model.

Table 46 presents a summary of those variables which explain the difference between low and high work injury costs for Texas chemical, paper and wood product firm respondents. The information indicates that those activities or variables which could together be called a safety program seem to most effectively reduce work injuries in the wood product industry where the cost of work injuries is higher than in the paper and chemical industries. Similarly, safety programs appear to most effectively reduce work injury costs in the smaller and medium-sized firms than in the larger firms where other factors seem to be of greater importance. The number of employees seems to be of great importance in the medium-sized firms and of less importance in large firms. Finally, the span of control explained from 15 to 23 percent of the cost of work injuries for large respondents. The proportion of  $R^2$  not explained by the variables included in the model selected in this multiple linear regression procedure might be explained by additional safety program variables not included in the model because they did not occur at satisfactory levels of probability, might be explained by variables not included in the model or might be explained by qualitative differences in the way safety and health loss control activities are carried out by different firms.

Table 47 provides summarized information about nine maximum  $R^2$  improvement multiple linear regression analyses made so comparisons can be made. This table indicates which variables were in the selected iteration, the sign of the B value of the variable and the contribution to  $R^2$  or portion of the variation explained by variables. A positive sign indicated that an increase in expenditures caused an increase in the dependent variable, the cost of work injuries. A negative sign indicated that an increase in expenditures for a given variable resulted in a decrease in the cost of work injuries.

Table 48 summarizes additional information about those variables which seem to most effectively reduce work injury costs for survey respondents. This information, based upon initial B values provided by the maximum  $R^2$  improvement multiple linear regression analyses of data, indicates that rules, training, medical, interest, and orientation are the individual variables which provide the greatest reduction of the cost of the work injuries of survey respondents.

Tables 49, 50 and 51 provide a listing in decreasing rank order of those variables which most effectively reduce work injuries for respondents in the chemical, paper and wood product industries. Once again these listings indicate that training, off-the-job and medical are the variables which are consistently ranked highest. These listings also indicate which variables appear to be least cost-effective. These variables are physicals, guarding, span of control, management and staff. Some comments about each of them are in

TABLE 46

Analysis of Those Variables Which Explain Differences Between  
Low and High Work Injury Costs for Texas Chemical,  
Paper and Wood Product Firm Respondents

| Size<br>of<br>Firm | <u>Chemical</u> |                | <u>Paper</u>   |                | <u>Wood Products</u> |                |
|--------------------|-----------------|----------------|----------------|----------------|----------------------|----------------|
|                    | Variable        | R <sup>2</sup> | Variable       | R <sup>2</sup> | Variable             | R <sup>2</sup> |
| Small              | Safety Program  | .78            | Safety Program | .95            | Safety Program       | .75            |
|                    | Not explained   | <u>.22</u>     | Employee No.   | .01            | Span Control         | .17            |
|                    |                 |                | Not explained  | <u>.04</u>     | Employee No.         | .02            |
|                    | Total           | 1.00           | Total          | 1.00           | Not explained        | <u>.06</u>     |
| Medium             | Safety Program  | .56            | Safety Program | .58            | Safety Program       | .66            |
|                    | Employee No.    | .18            | Employee No.   | .25            | Employee No.         | .32            |
|                    | Span Control    | .04            | Not explained  | <u>.17</u>     | Not explained        | <u>.01</u>     |
|                    | Not explained   | <u>.22</u>     | Total          | 1.00           | Total                | 1.00           |
| Large              | Safety Program  | .51            | Safety Program | .76            | Safety Program       | .65            |
|                    | Span Control    | .19            | Employee No.   | .15            | Span Control         | .23            |
|                    | Employee No.    | .13            | Span Control   | .05            | Employee No.         | .12            |
|                    | Not explained   | <u>.17</u>     | Not explained  | <u>.04</u>     | Not explained        | <u>.01</u>     |
|                    | Total           | 1.00           | Total          | 1.00           | Total                | 1.00           |

Source: Analysis of data, chemical run #42, paper run #29, wood products  
run #46 and #43

TABLE 47

Comparison of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis  
of the Effect of Selected Variables upon the Cost of Work  
Injuries per Employee for Texas Chemical, Paper and  
Wood Product Firm Respondents

| Size<br>of<br>Firm | <u>Chemical</u> |       |                | <u>Paper</u> |       |                | <u>Wood Products</u> |       |                |
|--------------------|-----------------|-------|----------------|--------------|-------|----------------|----------------------|-------|----------------|
|                    | Variable        | Sign  | R <sup>2</sup> | Variable     | Sign  | R <sup>2</sup> | Variable             | Sign  | R <sup>2</sup> |
| Small              | Staff           | +     | .30            | Guarding     | +     | .32            | Physicals            | +     | .25            |
|                    | Orientation     | +     | .21            | Records      | +     | .27            | Span Control         | -     | .17            |
|                    | Records         | -     | .10            | Off-the-Job  | +     | .16            | Meetings             | -     | .16            |
|                    | Inspections     | -     | .09            | Physicals    | -     | .11            | Interest             | +     | .11            |
|                    | Rules           | -     | <u>.08</u>     | Inspections  | +     | .05            | Training             | -     | .11            |
|                    |                 |       |                | Staff        | -     | .04            | Orientation          | -     | .12            |
|                    |                 |       |                | Employee No. | +     | <u>.01</u>     | Employee No.         | -     | <u>.02</u>     |
|                    | Total           |       | .78            | Total        |       | <u>.96</u>     | Total                |       | <u>.94</u>     |
| Medium             | Employee No.    | -     | .18            | Employee No. | +     | .25            | Orientation          | +     | .50            |
|                    | Meetings        | -     | .15            | Rules        | +     | .18            | Employee No.         | -     | .32            |
|                    | Interest        | +     | .13            | Guarding     | +     | .09            | Physicals            | +     | .09            |
|                    | Management      | -     | .11            | Orientation  | -     | .09            | Rules                | -     | .03            |
|                    | Training        | -     | .06            | Training     | -     | .07            | Records              | +     | .03            |
|                    | Equipment       | -     | .03            | Management   | +     | .07            | Training             | +     | .01            |
|                    | Orientation     | +     | .03            | Interest     | -     | <u>.06</u>     | Management           | -     | <u>.01</u>     |
|                    | Span Control    | -     | .03            |              |       |                |                      |       |                |
|                    | Off-the-Job     | -     | <u>.04</u>     |              |       |                |                      |       |                |
|                    |                 | Total |                | <u>.76</u>   | Total |                | .83                  | Total |                |

TABLE 47 (continued)

| Size of Firm | <u>Chemical</u> |      |                | <u>Paper</u> |      |                | <u>Wood Products</u> |      |                |
|--------------|-----------------|------|----------------|--------------|------|----------------|----------------------|------|----------------|
|              | Variable        | Sign | R <sup>2</sup> | Variable     | Sign | R <sup>2</sup> | Variable             | Sign | R <sup>2</sup> |
| Large        | Span Control    | -    | .19            | Off-the-Job  | -    | .31            | Physicals            | +    | .25            |
|              | Medical         | -    | .16            | Management   | +    | .21            | Span Control         | -    | .23            |
|              | Employee No.    | -    | .13            | Employee No. | -    | .15            | Medical              | -    | .23            |
|              | Staff           | +    | .10            | Span Control | -    | .15            | Staff                | +    | .16            |
|              | Training        | -    | .10            | Interest     | -    | <u>.14</u>     | Employee No.         | -    | <u>.12</u>     |
|              | Guarding        | +    | .04            |              |      |                |                      |      |                |
|              | Orientation     | +    | .04            |              |      |                |                      |      |                |
|              | Off-the-Job     | -    | <u>.04</u>     |              |      |                |                      |      |                |
|              | Total           |      | <u>.80</u>     | Total        |      | .96            | Total                |      | .99            |

TOT

Source: Analysis of data, chemical run #42, paper run #29 and wood product run #43 and #46

TABLE 48

Analysis of Those Variables Which Most Effectively Reduce Work Injury Costs for Texas Chemical, Paper and Wood Product Firm Respondents Based upon Initial B Values Provided by a Multiple Linear Regression Analysis

| Size of Firm | <u>Chemical</u> |                        | <u>Paper</u> |                        | <u>Wood Products</u> |                        |
|--------------|-----------------|------------------------|--------------|------------------------|----------------------|------------------------|
|              | Variable        | Return on \$1 Expended | Variable     | Return on \$1 Expended | Variable             | Return on \$1 Expended |
| Small        | Off-the-Job     | \$39                   | Off-the-Job  | \$358                  | Orientation          | \$106                  |
|              | Records         | 12                     | Interest     | 102                    | Training             | 100                    |
|              | Training        | 7                      | Physicals    | 33                     | Meetings             | 12                     |
|              | Rules           | 6                      | Orientation  | 5                      | Management           | 6                      |
|              | Inspections     | 5                      | Staff        | 3                      |                      |                        |
| Medium       | Management      | \$23                   | Medical      | \$ 97                  | Rules                | \$727                  |
|              | Off-the-Job     | 16                     | Training     | 46                     | Training             | 210                    |
|              | Rules           | 15                     | Equipment    | 16                     | Management           | 84                     |
|              | Medical         | 3                      | Interest     | 8                      | Medical              | 18                     |
|              | Equipment       | 2                      | Orientation  | 6                      | Staff                | 12                     |
|              | Training        | 2                      |              |                        | Interest             | 11                     |
|              | Meetings        | 2                      |              |                        |                      |                        |

TABLE 48 (continued)

| Size of Firm | <u>Chemical</u> |                        | <u>Paper</u> |                        | <u>Wood Products</u> |                        |
|--------------|-----------------|------------------------|--------------|------------------------|----------------------|------------------------|
|              | Variable        | Return on \$1 Expended | Variable     | Return on \$1 Expended | Variable             | Return on \$1 Expended |
| Large        | Off-the-Job     | \$22                   | Off-the-Job  | \$35                   | Medical              | \$37                   |
|              | Physicals       | 4                      | Records      | 11                     | Records              | 24                     |
|              | Inspections     | 2                      | Interest     | 10                     | Interest             | 14                     |
|              | Medical         | 2                      | Inspections  | 8                      |                      |                        |
|              | Training        | 2                      | Meetings     | 6                      |                      |                        |
|              |                 |                        | Training     | 2                      |                      |                        |

Source: Analysis of data, chemical run #42, paper run #29 and wood product run #46 and #43

TABLE 49

Decreasing Rank Order of the Effect of Selected Variables upon the Cost of Work Injuries per Employee in Texas Chemical Firm Respondents Based upon Initial 8 Values Provided by a Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis

|             | Size of Firm |              |
|-------------|--------------|--------------|
| Small       | Medium-Sized | Large        |
| Off-the-Job | Management   | Off-the-Job  |
| Records     | Off-the-Job  | Physicals    |
| Training    | Rules        | Inspections  |
| Rules       | Medical      | Medical      |
| Inspections | Equipment    | Training     |
| Guarding    | Training     | Guarding     |
| Management  | Meetings     | Span Control |
| Staff       | Span Control | Staff        |
| Orientation | Orientation  | Orientation  |
| Equipment   | Interest     | Records      |
| Physicals   | Physicals    | Interest     |
|             | Records      | Management   |

Source: Analysis of data, chemical, computer run #42

TABLE 50

Decreasing Rank Order of the Effect of Selected Variables upon the Cost of Work Injuries per Employee for Texas Paper Firm Respondents Based upon Initial B Values Provided by a Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis

|              | Size of Firm |              |
|--------------|--------------|--------------|
| Small        | Medium-Sized | Large        |
| Interest     | Medical      | Off-the-Job  |
| Physicals    | Training     | Records      |
| Orientation  | Equipment    | Interest     |
| Staff        | Interest     | Inspections  |
| Guarding     | Orientation  | Meetings     |
| Span Control | Span Control | Training     |
| Inspections  | Guarding     | Span Control |
| Meetings     | Inspections  | Staff        |
| Management   | Physicals    | Orientation  |
| Medical      | Management   | Management   |
| Records      | Rules        |              |

Source: Analysis of data, paper, computer run #29

TABLE 51

Decreasing Rank Order of the Effect of Selected Variables upon the Cost of Work Injuries per Employee for Texas Wood Product Firm Respondents Based upon Initial B Values Provided by a Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis

|              | Size of Firm |              |
|--------------|--------------|--------------|
| Small        | Medium-Sized | Large        |
| Orientation  | Rules        | Medical      |
| Training     | Management   | Records      |
| Meetings     | Medical      | Interest     |
| Management   | Staff        | Span Control |
| Span Control | Interest     | Meetings     |
| Rules        | Guarding     | Guarding     |
| Equipment    | Meetings     | Physicals    |
| Physicals    | Orientation  | Orientation  |
| Interest     | Physicals    | Staff        |
|              | Records      | Training     |
|              |              | Equipment    |
|              |              | Rules        |
|              |              | Management   |

Source: Analysis of data, wood products, computer run #46 and #43

order to provide some additional reasons why these variables might be less cost-effective than some of the other variables. The first variable discussed is orientation. The Pearson product-moment correlation coefficients relating turnover to orientation was significant at a probability of 0.10 or less in seven of the nine cells in the study. These coefficients and their probabilities are provided in Table 52. Therefore, one reason why high costs of orientation might occur in those organizations in which high costs of work injuries occurred is that the higher numbers of additions to staff and greater turnover in such firms required a higher orientation expense. Similarly, one reason why the cost of physical examinations were greater in those firms with high work injury costs might be that these costs are related to additions to staff and to turnover which occurred more frequently in such firms. Span of control, defined in the study as the monetary cost of supervision to firms, correlated with lower costs of work injuries but not at a high enough level to provide a B value of one or greater in seven of the nine cells. Therefore, based upon this study, additional supervisory personnel could not be justified solely by the estimated reductions in the costs of work injuries. However, if such additional personnel could be at least partially justified for other reasons such as improvements in productivity or the improved quality of products, then these factors coupled with a partial justification in terms of the reduced cost of work injuries to employers might make the provision of additional supervisory personnel desirable to employers. As previously indicated, the variable management might not be the best measure of this element. Qualitative measures described in Chapter IV are more appropriate ways of assessing this factor. For these reasons no special significance is attached to the fact that in six of the nine cells higher management costs partially explained the higher costs of work injuries and that in the three remaining cells it helped explain the reasons some firms experienced lower work injury costs. In six of the nine cells, the monetary cost of guarding, the correction of unsafe physical conditions which could affect employee safety or health, was not cost-effective and in the remaining three cells no relationships were found. Reasons for this might be that those firms with poorer safety performances were spending greater sums of money to correct existing poorer physical conditions or that expenditures of this type are not as cost-effective as other expenditures. No relationships were found between the age of facilities and the cost of work injuries per employee. Therefore, it appears that expenditures of this type are not as cost-effective as many of the other kinds of expenditures.

A last group of variables were cost-effective in some cells and were not cost-effective in others. These are rules, meetings, inspections, equipment and records. A further analysis of all of these variables is provided in Chapter VI.

The information was also analyzed in a third way. The activities and records of various combinations of firms were compared to each other. Also, the effect of the most important variables and their combinations was analyzed.

First, the results of maximum  $R^2$  improvement multiple linear regression analyses for all of the large, medium-sized and small survey respondents regardless of industry will be presented. Tables 53 and 54 provide this information for all of the large respondents. Table 53 provides information

TABLE 52

Pearson Product-Moment Correlation Coefficients Relating Turnover to  
Other Variables for Texas Chemical, Paper and  
Wood Product Firm Respondents

| Firm<br>Size | <u>Chemical</u> |                 |       | <u>Paper</u> |                 |             | <u>Wood Products</u> |                 |       |
|--------------|-----------------|-----------------|-------|--------------|-----------------|-------------|----------------------|-----------------|-------|
|              | Variable        | Corr.<br>Coeff. | Prob. | Variable     | Corr.<br>Coeff. | Prob.       | Variable             | Corr.<br>Coeff. | Prob. |
| Small        | Records         | .74             | .001  | Orientation  | .72             | .008        | Orientation          | .40             | .08   |
|              | Physical        | .62             | .008  | Interest     | .64             | .02         | Medical              | .36             | .12   |
|              | Span Control    | .56             | .02   | Off-the-Job  | .66             | .02         | Performance          | .35             | .13   |
|              | Interest        | .42             | .09   | Physicals    | .60             | .04         |                      |                 |       |
|              | Medical         | .41             | .10   |              |                 |             |                      |                 |       |
| Medium       | Performance     | .47             | .03   | Span Control | .53             | .04         | Orientation          | .81             | .001  |
|              | Orientation     | .43             | .05   | Interest     | -.46            | .08         | Performance          | .65             | .007  |
|              |                 |                 |       | Physicals    | .46             | .08         | Span Control         | -.47            | .08   |
| Large        | Orientation     | .81             | .001  | Orientation  | .84             | .001        | Orientation          | .81             | .008  |
|              | Rules           | .56             | .02   | Management   | .77             | .005        | Management           | .69             | .01   |
|              |                 |                 |       | Performance  | .68             | .02         | Staff                | .73             | .01   |
|              |                 |                 |       |              |                 |             | Physicals            | .69             | .02   |
|              |                 |                 |       |              |                 | Performance | .60                  | .05             |       |

Source: Analysis of data, chemical run #29, paper run #19, and wood product #33

TABLE 53

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis of the Effect of Selected Variables upon the Cost of Work Injuries per Employee for Large Texas Chemical, Paper and Wood Product Firm Respondents

| Variable     | B Value | Probability | Std. Error B | Addition to R <sup>2</sup> | Cumulative R <sup>2</sup> |
|--------------|---------|-------------|--------------|----------------------------|---------------------------|
| Employee No. | - .20   | .01         | .08          | .15                        | .15                       |
| Physicals    | 6.55    | .001        | 1.43         | .26                        | .41                       |
| Span Control | - .21   | .01         | .08          | .12                        | .53                       |
| Medical      | - 1.89  | .01         | .72          | .07                        | .60                       |
| Meetings     | - .70   | .10         | .42          | .02                        | .62                       |
| Staff        | 1.23    | .16         | .87          | .02                        | .64                       |

Source: Analysis of data, combinations, computer run #9A, 6 variable model

TABLE 54

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis of the Effect of Selected Variables upon the Cost of Work Injuries per Employee in Terms of Initial B Values for Large Texas Chemical, Paper and Wood Product Firm Respondents

| Variable     | Initial<br>B Value | Probability | Std.<br>Error B |
|--------------|--------------------|-------------|-----------------|
| Employee No. | - .24              | .01         | .09             |
| Management   | 18.53              | .28         | 17.12           |
| Staff        | 1.23               | .16         | .87             |
| Orientation  | 1.07               | .18         | .80             |
| Rules        | - 21.05            | .24         | 17.66           |
| Interest     | *                  |             |                 |
| Meetings     | - .55              | .18         | .41             |
| Inspections  | - 2.33             | .13         | 1.52            |
| Equipment    | *                  |             |                 |
| Guarding     | *                  |             |                 |
| Physicals    | 6.85               | .001        | 1.68            |
| Medical      | - 1.86             | .01         | .72             |
| Off-the-Job  | *                  |             |                 |
| Training     | *                  |             |                 |
| Records      | *                  |             |                 |
| Span Control | - .22              | .005        | .07             |

\*Did not enter the model or entered it at a low probability

Source: Analysis of data, combinations, computer run #9A

about the selected iteration or model and Table 54 provides information about the initial B value for each variable which appeared in any iteration of the procedure provided the value occurred at a reasonably satisfactory level of probability. Similar information about all of the medium-sized firms in the study is provided in Tables 55 and 56. The  $R^2$  for the selected iteration was 0.28 and initial B values with a probability of 0.30 or less occurred for only six of the sixteen variables. The results indicate that there are many differences between the practices of medium-sized chemical, paper and wood product firm respondents. Still wider variations occurred when small chemical, paper and wood product firms were compared. The most satisfactory model was the two variable model which consisted of the variables employee number and span of control. In this model the  $R^2$  was 0.04.

Finally, the results of a maximum  $R^2$  improvement multiple linear regression analysis of the effect the six variables which provided the greatest contribution to  $R^2$  and of their combinations upon the dependent variable is provided. This information is not primarily provided to further explain the results of the research but is provided to give some indications of the interdependence of the independent variables in the model. This interdependence or multicollinearity, according to the Statistical Package for the Social Sciences, "refers to the situation in which some or all of the independent variables are very highly intercorrelated."<sup>3/</sup> The six variables selected in the chemical industry were employee number, staff, orientation, medical, training and records. The variables selected for use in an analysis of the paper and wood product industries were employee number, management, rules, training, meetings, and guarding. Table 57 provides a comparison of  $R^2$  values and the number of variables in the selected iterations for the analyses made. This indicates that almost all of the variation is explained by these variables and their combinations. Table 58 provides a listing of the selected and combined variables which entered the selected iteration. This table also provides the sign of the B value for each variable. A negative sign again indicates that an increase in the monies spent for a given variable caused a reduction in the cost of work injuries which is the dependent variable. Finally, as has been done in other tables, the  $R^2$  or proportion of the variation explained by each of the variables is provided. This information primarily points up the interdependence of variables and does not provide further useful information about the relationship of the independent variables to the cost of work injuries for survey respondents.

### Conclusion

This chapter summarized the quantitative results of this research in order to test hypotheses about the relationships between the cost of various loss control activities provided by firms and the cost of resulting work

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<sup>3/</sup> N. H. Nie, C. H. Hull, J. G. Jenkins, K. Steinbrenner and D. H. Bent, Statistical Package for the Social Sciences (New York: McGraw-Hill, 1975), p. 340, Ref. (54)

TABLE 55

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis of the Effect of Selected Variables upon the Cost of Work Injuries per Employee for Medium-Sized Texas Chemical, Paper and Wood Product Firm Respondents

| Variable     | B Value | Probability | Std. Error B | Addition to R <sup>2</sup> | Cumulative R <sup>2</sup> |
|--------------|---------|-------------|--------------|----------------------------|---------------------------|
| Employee No. | - 3.97  | .04         | 1.88         | .11                        | .11                       |
| Orientation  | 15.79   | .005        | 5.39         | .10                        | .21                       |
| Equipment    | - 3.64  | .10         | 2.18         | .06                        | .27                       |
| Meetings     | - 2.45  | .31         | 2.40         | .01                        | .28                       |

Source: Analysis of data, combinations computer run #10A, 4 variable model

TABLE 56

Results of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis of the Effect of Selected Variables upon the Cost of Work Injuries per Employee in Terms of Initial B Values for Medium-Sized Texas Chemical, Paper and Wood Product Firm Respondents

| Variable     | Initial<br>B Value | Probability | Std.<br>Error B |
|--------------|--------------------|-------------|-----------------|
| Employee No. | - 4.71             | .01         | 1.86            |
| Management   | *                  |             |                 |
| Staff        | - 2.45             | .17         | 1.79            |
| Orientation  | 13.35              | .01         | 5.30            |
| Rules        | -38.60             | .19         | 29.35           |
| Interest     | *                  |             |                 |
| Meetings     | - 2.45             | .31         | 2.40            |
| Inspections  | *                  |             |                 |
| Equipment    | - 4.13             | .05         | 2.12            |
| Guarding     | *                  |             |                 |
| Physicals    | *                  |             |                 |
| Medical      | *                  |             |                 |
| Off-the-Job  | *                  |             |                 |
| Training     | *                  |             |                 |
| Records      | *                  |             |                 |
| Span Control | *                  |             |                 |

\*Did not enter the model or entered it at a low probability

Source: Analysis of data, combinations, computer run #10A

TABLE 57

Comparison of R<sup>2</sup> Values Computed by a Multiple Linear Regression Analysis of the Effect of Selected Variables and Their Combinations upon the Cost of Work Injuries per Employee for Texas Chemical, Paper and Wood Product Firm Respondents

| Industry      | Size of Firm   |                              | Size of Firm   |                              | Size of Firm   |                              |
|---------------|----------------|------------------------------|----------------|------------------------------|----------------|------------------------------|
|               | <u>Large</u>   | Number of Variables in Model | <u>Medium</u>  | Number of Variables in Model | <u>Large</u>   | Number of Variables in Model |
|               | R <sup>2</sup> |                              | R <sup>2</sup> |                              | R <sup>2</sup> |                              |
| Chemical      | .99            | 7                            | .99            | 6                            | .99            | 6                            |
| Paper         | .999           | 5                            | .996           | 5                            | .998           | 5                            |
| Wood Products | .99            | 6                            | .98            | 6                            | .998           | 5                            |

Source: Analysis of data, chemical run #47, paper run #31, and wood products run #48

TABLE 58

Comparison of the Maximum R<sup>2</sup> Improvement Multiple Linear Regression Analysis of the Effects of Selected and Combined Variables upon the Cost of Work Injuries per Employee for Texas Chemical, Paper and Wood Product Firm Respondents

| Size of Firm | <u>Chemical</u> |      |                | <u>Paper</u> |      |                | <u>Wood Products</u> |      |                |
|--------------|-----------------|------|----------------|--------------|------|----------------|----------------------|------|----------------|
|              | Variable        | Sign | R <sup>2</sup> | Variable     | Sign | R <sup>2</sup> | Variable             | Sign | R <sup>2</sup> |
| Small        | STAREC          | +    | .61            | RULGUA       | +    | .95            | EMPMEE               | +    | .85            |
|              | MEDREC          | -    | .22            | TNGMEE       | +    | .04            | GUARD                | +    | .13            |
|              | ORIREC          | -    | .08            | MGMRUL       | -    |                | RULGUA               | -    | .01            |
|              | REC             | +    | .03            | MEET         | +    |                | MEET                 | +    |                |
|              | EMPREC          | -    | .03            | MGMEE        | -    |                | EMPTNG               | +    |                |
|              | STA             | +    | .02            | EMPMEE       | -    |                | EMPGUE               | +    |                |
|              | TNG             | +    | .01            | EMPRUL       | +    |                | RULMEE               | +    |                |
| Medium       | REC             | +    | .65            | MEET         | +    | .67            | RULMEE               | +    | .83            |
|              | TNG             | +    | .18            | GUARD        | +    | .15            | MGMTNG               | +    | .06            |
|              | EMPTNG          | -    | .12            | TNGMEE       | +    | .12            | EMPMEE               | +    | .02            |
|              | EMPREC          | +    | .02            | RULMEE       | +    | .03            | EMPGUA               | +    | .02            |
|              | ORITNG          | -    | .01            | MGMEE        | +    | .01            | MEET                 | +    | .02            |
|              | STAREC          | +    |                | EMPTNG       | -    | .01            | EMPTNG               | -    | .02            |
|              | STAMED          | +    |                | TNG          | -    | .01            | MGMRUL               | -    | .02            |

TABLE 58 (continued)

| Size<br>of<br>Firm | <u>Chemical</u> |      |                | <u>Paper</u> |      |                | <u>Wood Products</u> |      |                |
|--------------------|-----------------|------|----------------|--------------|------|----------------|----------------------|------|----------------|
|                    | Variable        | Sign | R <sup>2</sup> | Variable     | Sign | R <sup>2</sup> | Variable             | Sign | R <sup>2</sup> |
| Large              | STAREC          | +    | .88            | TNGGUA       | +    | .97            | TNG                  | +    | .75            |
|                    | STA             | -    | .06            | EMPME        | +    | .02            | TNGGUA               | +    | .11            |
|                    | TNG             | -    | .02            | EMPMGM       | -    |                | MGMME                | +    | .11            |
|                    | MEDREC          | -    | .01            | RULGUA       | +    |                | MGMT                 | -    | .01            |
|                    | STAMED          | +    | .01            | MGMGUA       | +    |                | GUARD                | +    | .01            |
|                    | MED             | -    | .01            | MGMT         | +    |                | MGMGUA               | +    | .01            |
|                    | EMPTNG          | -    |                | GUARD        | +    |                |                      |      |                |

Note: In this table variable code names are the first three letters of the name of a variable. The code names of combinations of variables are the first three letters of the two variables combined.

Source: Analysis of data, chemical run #47, paper run #31, and wood product run #48

injuries for Texas survey respondents. Information about the monetary cost of these activities and of the cost of work injuries to reporting firms was detailed. Three general ways in which these costs were compared have been described and the results of these comparisons have been provided.

## CHAPTER VI

### CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

#### Introduction

Three types of information are provided in this chapter. First, conclusions reached as a result of the study are listed and the evidence which supports them is briefly reviewed. Second, some of the implications of this research are discussed. Third, some recommendations for further research are provided.

#### Conclusions Reached as a Result of the Research

A fairly large number of conclusions have been reached as a result of this study. Some of these conclusions are in regard to the hypotheses made before the research was begun and other conclusions have been reached after a further review of the data in the study.

Before these conclusions are reviewed, a clarifying statement about the hypotheses and the research is in order. The research has not separately examined those activities and losses which were related to work injuries and those which were related to occupational diseases. Available information which was reviewed in Chapter II indicates that most of the reported incidents and most of the direct cost of work injuries and illnesses pertain to work injuries and not to occupational diseases or work illnesses. Therefore, the conclusions reached as a result of this study are judged to pertain only to ways in which work injuries can be reduced and prevented. The author believes that the generally accepted techniques of recognition, evaluation and control of environmental hazards represent the best known way to control occupational diseases at this time.

The hypotheses made and the evidence pertaining to them are now presented. The first hypothesis stated both as a null hypothesis and as an alternate hypothesis is as follows:

$H_0$ : There is no relationship between the cost of safety and health loss control activities and the cost of work injuries for firms in selected Texas industries.

$H_1$ : There is a relationship between the cost of safety and health loss control activities and the cost of work injuries for firms in selected Texas industries.

This research partially supports the second or the alternate hypothesis, and partially rejects it. When industry costs were compared to each

other, a relationship was found between the monies which firms in an industry spend to reduce work injuries and the monetary costs of the resulting work injuries. Specifically, firms in the chemical industry spent relatively large amounts of money to prevent work injuries in 1974 and experienced relatively less costly work injuries. Wood product firms spent relatively less to prevent work injuries and experienced relatively high work injury costs. Finally, paper product manufacturing firms expended moderate amounts of money to reduce work injuries and experienced more moderate work injury costs. This information is provided in graphic form in Figure 11 (p. 115). Table 59 presents these same monetary costs as a percent of hourly employee average annual wages in order to provide another evaluation of the magnitude of these costs. This information indicates that the total average cost of both safety activities and of work injuries was 8.4% of average hourly labor wage costs for chemical firms, 7.1% for paper manufacturers and 13.7% for wood product respondents. A closer examination of these costs was made when the costs of loss control programs for those firms with low injury costs and with high injury costs were compared to each other. Figures 12-14 (pp. 116-118) show these relationships in visual form. These graphs show that in seven of the nine different groupings of data by size and by industry, firms with fewer work injuries also expended somewhat less monies on their safety programs. Therefore, while the alternate hypothesis has been proven in the aggregate it has been rejected for most groupings of firms by size in the industries studied.

The second hypothesis, again stated as both a null hypothesis and as an alternate hypothesis, follows:

- $H_0$ : There is no relationship between the cost of various individual safety and health loss control activities and the cost of work injuries for firms in selected Texas industries.
- $H_1$ : There is a relationship between the cost of various individual safety and health loss control activities and the cost of work injuries for firms in selected Texas industries.

The bulk of this study has been concerned with this hypothesis which has been stated in these two ways. The loss control activities or variables identified in this study are top management activities, safety staff, new employee orientation, safety rules, activities to maintain interest, safety meetings, safety inspections, personal protective equipment, guarding, physical examinations, medical supplies and personnel, off-the-job safety, training experienced employees, and the maintenance of records of injuries and illnesses. Three non-quantitative respondent evaluations indicated that top management interest and activities were an important part of an effective safety program. These three were a chi-square statistical test relating higher management interest to those firms with better safety performances, a high priority assigned to top management activities when respondents compared the various safety activities to each other and a number of subjective comments made by respondents and reported in Chapter IV. Chapter IV also provided a rank ordering of all of the various safety program activities judged by respondents to be most effective. The last section of this chapter provided a number of general comments made by respondents about the relative value of various loss control activities. Chapter V provided quantitative measures of these

TABLE 59

The Total Cost of Safety Activities and of Work Injuries in Terms of Percent of Hourly Employee Average Annual Wages for Texas Chemical, Paper and Wood Product Firm Respondents

| Item   | Type of Firm |        |               |
|--|--------------|--------|---------------|
|  | Chemical     | Paper  | Wood Products |
| Hourly Employee Average Annual Wages               | \$10,092     | \$8136 | \$6274        |
| Safety Activity Cost as Percent of Wages           | 6.1%         | 3.3%   | 3.1%          |
| Work Injury Cost as Percent of Wages               | 2.3%         | 3.8%   | 10.6%         |
| Both Activity and Injury Costs as Percent of Wages | 8.4%         | 7.1%   | 13.7%         |
| Source: Analysis of data                           |              |        |               |

same relationships. The first series of tables in this chapter described the results of maximum  $R^2$  improvement multiple linear regression analyses of the relationships. The last series of tables in Chapter V summarized the results of these analyses. This information indicated that from five to nine of the variables entered the nine multiple linear regressions performed for the three groupings of respondents by size in each of the three industries studied. These nine multiple linear regression analyses showed that there was a relationship between many of the loss control activities and the cost of work injuries. These loss control activities explained from 0.51 to 0.95 of the variation between the work injury costs of firms of the same size grouping in the same industry as measured by the  $R^2$  statistic.

One last analysis of this data was made. An analysis of variance was calculated in order to evaluate the sources of differences between the costs of work injuries per employees for firms studied. The results of this analysis are summarized in Table 60. This information indicates that 0.54 of the variation in the cost of work injuries per employee as measured by the  $R^2$  statistic was explained by the experimental design of the research. In this study firms were grouped by work injury rate classifications within size categories within three different industries. Differences between injury rate classifications explained approximately one quarter of the variation or 0.22. Differences between industries explained 0.12 of the total variance, the size category explained an additional 0.02 and interactions added 0.18. The remainder of the variance, 0.46 as measured by the  $R^2$  statistic, was caused by differences between the work injury costs of firms grouped in the same cell and has been labeled error. This review of the research design provides useful insights into the sources of variation in work injury costs. The analysis indicates that, based upon this research, business firms do have control over the largest proportion of those factors which taken together determine the cost of their injuries.

A number of other conclusions have also been reached. These are essentially conclusions beyond those which were reached as a result of the testing of the two hypotheses.

As a result of this research it was found that different combinations of loss control activities explained the differences between low and high work injury costs for firms. This occurred both for firms of different sizes in the same industry and for firms of the same size grouping in different industries. When the information about all chemical firms was compared by means of a multiple linear regression analysis an  $R^2$  of 0.22 was obtained. A similar analysis of paper industry data provided an  $R^2$  value when variables entered the model at satisfactory levels of probability of 0.28. In the wood product industry a similar  $R^2$  value was 0.26. When information about all of the large firms was compared by the multiple linear regression procedure the  $R^2$  was 0.64. When medium-sized firms were compared the  $R^2$  was calculated to be 0.28 and when the data from all small firm respondents were analyzed an  $R^2$  of 0.05 occurred. When this same information from respondents of the same size grouping in the same industry was similarly evaluated much larger proportions of the variation between the work injury costs of firms was explained. These analyses produced  $R^2$  statistics ranging from 0.78 to 0.99. Therefore, different combinations of variables in different industries and for different sized firms explain differences in work injury costs.

TABLE 60

Analysis of Variance of the Safety Performance of Texas Chemical,  
Paper and Wood Product Firm Respondents as Measured by  
Cost of Work Injuries and Illnesses per Employee

| Source of Variance          | Degrees of Freedom | Sum of Squares | Mean Square | F Value | Prob. F | R <sup>2</sup> |
|-----------------------------|--------------------|----------------|-------------|---------|---------|----------------|
| Total                       | 140                | 48,241,721     | 344,583     |         |         |                |
| Regression                  | 17                 | 25,957,258     | 1,526,897   | 8.43    | .001    | .54            |
| Industry                    | 2                  | 5,588,511      | 2,794,255   | 15.43   | .001    | .12            |
| Size                        | 2                  | 1,110,142      | 550.071     | 3.03    | .06     | .02            |
| Industry x Size             | 4                  | 838,928        | 209,732     | .61     | .66     | .02            |
| Frequency Rate              | 1                  | 10,872,017     | 10,872,017  | 60.06   | .001    | .22            |
| Industry x Frequency        | 2                  | 2,811,965      | 1,405,982   | 7.76    | .001    | .06            |
| Size x Frequency            | 2                  | 255,708        | 127,854     | .63     | .54     | .01            |
| Industry x Size x Frequency | 4                  | 4,494,987      | 1,123,747   | 6.20    | .001    | .09            |
| Error                       | 123                | 22,284,463     | 181,174     |         |         |                |

Source: Analysis of data, combinations, computer run #14A

A second major additional finding reached as a result of this study was in regard to the relative effectiveness of safety programs. Approximately 0.60 of the variation between the injury costs for firms of the same size in the same industry as measured by  $R^2$  was explained by the safety programs of large and medium-sized firms. These safety programs explained approximately 0.80 of the variation in the records of small firms again as measured by the  $R^2$  statistic. Remaining differences were explained by variations in the number of employees in firms within a size grouping, by a monetary measure of the span of control or were not explained. Variations which were not explained might be caused by qualitative differences between the various safety programs, by other factors which were not included in this study or by random error.

Third, those safety and health loss control activities which most effectively reduced work injuries for survey respondents were identified. This selection was based both on the relative cost-effectiveness of variables in each of the nine cells and on the proportion of the variation explained by the variables or the contribution to  $R^2$ . Cost-effectiveness was defined in this study as monetary expenditures for safety which provided the greatest reductions in work injury costs. The most effective variables as measured in this manner and listed in decreasing order of importance were: safety rules, off-the-job safety, safety training, safety orientation, safety meetings and medical supplies and personnel. Higher monetary costs of supervision per employee or as defined in this study, span of control, consistently correlated with low work injury costs. However, decreased work injury costs alone did not provide sufficient justifications for increasing expenditures of this type. Those variables found to be least cost-effective, again ranked in decreasing rank order, were: records, physical examinations, activities to maintain interest, safety staff, guarding, inspections and personal protective clothing provided by employers.

Fourth, a review of the results of the research suggested that there was strong interdependence between variables or a great deal of multicollinearity. This interdependence was evaluated when the six most important variables and all possible combinations of them were compared to the cost of work injuries by the multiple linear regression procedure. These six variables and their combinations explained from 0.99 to 0.999 of the variation in the cost of work injuries as stated in terms of the  $R^2$  statistic.

To conclude, this research points to the importance of subtle combinations of highly interrelated safety and health loss control activities which most effectively reduce work injuries. It also indicates that a more appropriate mix of these activities rather than increase in monetary expenditures for all of them or for any one of them most effectively reduces work injury costs. This correct mix seems to consist of sufficient expenditures for safety rules, off-the-job safety, safety training, safety orientation, safety meetings, medical supplies and staff and of good top management interest and participation in safety.

The most effective mix of these elements of a safety program would appear to be a balanced approach which combines both engineering and non-engineering activities and which probably places the greatest emphasis on the non-engineering aspects. Three pertinent comments about this balanced approach

are provided in order to provide the perceptions of others on this subject. Vincent Tofany, President of the National Safety Council, addressed a session of the National Safety Congress on October 3, 1975. At that time he said that the time has come "to talk about safety and health in more balanced terms."1/ He continued, stating that "the real issue is not compliance with the Occupational Safety and Health Act and its regulations but safety and health in the workplace. ...Compliance will contribute to safety but far more is needed... OSHA regulations must be based on what is enforceable which generally means what is measureable...good management, company training and morale of workers are not measurable but are the 'bread and butter' of a safety and health program."2/ He concluded by stating that "employers should obey OSHA and make the standards the rule of the workplace, but they also must maintain a complete safety and health program.... One accident will punish an employer much more severely than any penalty the Occupational Safety and Health Administration assesses."3/

Second, in an article in the March 1975 issue of Professional Safety entitled "OSHA in Perspective" (45) Michael Krikorian, Corporate Manager of Safety, the Brunswick Corporation and a past national president of the American Society of Safety Engineers provided another pertinent comment. He suggested that "the law (OSH Act) needs to be rewritten to include provisions to require all employers to establish employee protection (safety) programs whose sole purpose and objective shall be the prevention of accidental injuries and illnesses. OSHA would then have the task of identifying those elements which would constitute an acceptable accident-prevention program."4/ Third, Drs. Alexander Cohen, Michael Smith and H. Harvey Cohen of the the National Institute for Occupational Safety and Health in Safety Program Practices in High Vs. Low Accident Rate Companies - An Interim Report (17) conclude in part that "...low accident companies, relative to their high accident cohorts, show more of the following: ...A safety program emphasizing better balance between engineering and non-engineering approaches toward accident prevention and control."5/

This study concludes that a balanced approach toward the reduction of work injuries utilizing a prudent mix of those factors found by this research to

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- 1/ V.L. Tofany, "A Balanced Approach to Safety and Health," Occupational Safety and Health Reporter, 5 (October 9, 1975), p. 576, Ref. (78)
  - 2/ Ibid., p. 576.
  - 3/ Ibid., p. 577.
  - 4/ M. Krikorian, "OSHA in Perspective," Professional Safety, 20 (March 1975), p. 24, Ref. (45).
  - 5/ A. Cohen, M. Smith and H. Cohen, Safety Program Practices in High Vs. Low Accident Rate Companies - An Interim Report (Cincinnati: U.S. Department of Health, Education and Welfare, 1975), p. 68, Ref. (17).

be effective tempered by the past experience of an organization is the most effective approach to the solution of this problem at this time. Again, because most of the numbers and costs of reported work injuries and occupational diseases pertain to work injuries and not to occupational diseases and since there seems to be a fairly clear cause and effect relationship between engineering controls provided and resulting occupational diseases, these conclusions and recommendations are directed toward only the control of work injuries.

#### Implications of the Research

The research has specific implications for business firms, for the public regulation of occupational safety and health by governmental agencies and for public policy established by governmental bodies and by others. First, and perhaps most important, are the implications for business firms. This research was undertaken to attempt to provide an economic analysis that might provide useful information for such organizations. As previously indicated, these results should be of unusual interest to Texas chemical, paper and wood product manufacturing firms because they describe and analyze the occupational safety and health activities and performance of many of these organizations in some depth. These results should also be of significant interest to other chemical, paper and wood product manufacturers in other parts of the United States because of the similarity of these operations to those in Texas. The study may also be of interest to other manufacturing firms because the industries studied are similar to a number of the other manufacturing industries. The research may also provide some insights for those who are with other types of business organizations primarily because so few of such studies have been made.

Second, there are implications in the research for the activities of Federal and State occupational safety and health regulatory agencies, specifically the Federal Occupational Safety and Health Administration and the Federal National Institute for Occupational Safety and Health. If these findings are judged to provide additional understandings, then a more balanced approach toward the regulation of occupational safety in the private sector would be appropriate. The purpose of the Occupational Safety and Health Act of 1970 "...is to assure so far as possible every working man and woman in the nation safe and healthful working conditions and to preserve our human resources."<sup>6/</sup> These results show that additional emphasis should be placed upon the encouragement of employers to provide safety rules, training, orientation, and meetings, to provide off-the-job safety activities and to provide additional medical staff and facilities as needed. Such broadened safety programs could be encouraged by full audits of the programs of firms visited, by educational activities emphasizing these aspects and possibly by some form of tax incentive to encourage more activity in these directions.

Third, there may be some implications in this research for those individuals and for those governmental bodies which set public policy. These implications

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<sup>6/</sup> U.S. Congress, P.L. 91-596, The Occupational Safety and Health Act of 1970 (Washington, D.C.: Government Printing Office, 1971), p. 1, Ref. (82A).

are of two types. First, this research indicates that some reallocation of the monies spent and of efforts made can reduce the economic losses caused by work injuries to business firms, to society and to individuals. In this time of increasing economic pressures upon firms and upon the nation for a fuller utilization of resources such a reallocation should be carefully considered.

Second, this research seems to indicate that the monetary costs of work injuries are only one factor among several which determine the emphasis which certain business manufacturing firms place on occupational safety. These results would seem to reinforce a conclusion reached by the National Commission on State Workmen's Compensation Laws. This conclusion was that "...this lack of evidence to demonstrate that accident rates decline as experience rating becomes more powerful suggests that other forces which influence safety records are stronger than potential savings in premiums which can result from a superior safety record."<sup>7/</sup>

#### Recommendations for Further Research

This research is the first quantitative evaluation of the experience of a reasonably large number of firms known to have been performed. It has involved only a sample of 140 Texas chemical, paper and wood product firms. Additional research to similarly measure the safety activities and safety performances of organizations in other industries should be undertaken. Similar studies surveying representative types of firms in the service industry, firms in the contract construction, in the electric, gas, transportation and communication sector and in mining would be desirable in order to evaluate ways in which work injuries and illnesses can most effectively be prevented in these sectors. Research to evaluate manufacturing firms in other parts of the nation would also be desirable both to provide a replication of this study and to evaluate possible differences between geographic areas and among industries. Finally, specific research to try to establish quantitative relationships between both additions to staff or accessions and turnover and the cost of work injuries to firms would also appear to be desirable.

#### Conclusion

This research has consisted of a detailed examination of the occupational safety and health loss control activities and of the work injuries and illnesses reported by selected Texas manufacturing firms during 1974. The research has provided both qualitative and quantitative evaluations of these factors.

The author sincerely hopes that this study will provide additional useful understandings of the complex question of how work injuries can be reduced and eliminated by organizations. Of greater importance, it is hoped that this research will stimulate others to find more effective approaches and more complete answers to this important question.

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APPENDIX A

THE COVER LETTER DATED APRIL 2, 1975 SENDING  
THE SURVEY INSTRUMENT TO FIRMS SAMPLED

TEXAS A&M UNIVERSITY  
COLLEGE OF BUSINESS ADMINISTRATION  
COLLEGE STATION, TEXAS 77843

Department of  
MANAGEMENT

April 2, 1975

Dear Sir:

One of the significant problems which many Texas employers currently face is occupational safety and health -- how to reduce work injuries and occupational diseases and how to comply with the requirements of the Federal Occupational Safety and Health Act of 1970.

The Department of Management, College of Business Administration, Texas A&M University, is making a study to attempt to determine which safety activities most effectively reduce work injuries.

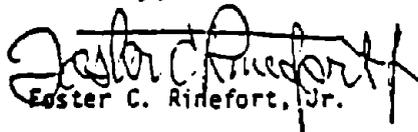
Your help is needed. Your responses to questions on the enclosed questionnaire will help us find some answers to this important question.

Information obtained will be coded so respondents cannot be identified and will be kept strictly confidential.

Would you please complete the questionnaire as completely as you can. Then return it to me in the enclosed stamped envelope as soon as possible.

A summary of results obtained will be sent to those who would like this information. Thank you in advance for your help.

Sincerely,

  
Easter C. Rinefort, Jr.

APPENDIX B

THE SURVEY INSTRUMENT: SURVEY OF OCCUPATIONAL  
SAFETY AND HEALTH ACTIVITIES AND PERFORMANCE

**SURVEY OF OCCUPATIONAL SAFETY AND HEALTH  
ACTIVITIES AND PERFORMANCE**

Conducted By  
Foster C. Rinefort, Jr.

College of Business  
Texas A&M University

The purpose of this study is to survey business organizations in Texas in order to more precisely measure the effects of various loss control activities upon the safety record of such organizations. This information will better enable organizations to direct their time and monies to most effectively control and prevent work injuries. All information obtained will be coded so respondents cannot be identified and will be kept STRICTLY CONFIDENTIAL. Please answer applicable questions as fully as possible.

OCCUPATIONAL SAFETY AND HEALTH LOSS CONTROL ACTIVITIES

1. Who has the responsibility of developing your safety and health program? (9-10)  
(Please rank in order of time and effort contributed)

|                                     |                               |
|-------------------------------------|-------------------------------|
| _____ Own staff (a)                 | _____ Association staff (d)   |
| _____ Corporate or headquarters (b) | _____ Outside consultants (c) |
| _____ Insurance carriers (e)        | _____ Other _____             |

2. Who has the responsibility of carrying out your safety and health program? (11-12)  
(Please rank in order of time and effort contributed)

|                                     |                               |
|-------------------------------------|-------------------------------|
| _____ Own staff (a)                 | _____ Association staff (d)   |
| _____ Corporate or headquarters (b) | _____ Outside Consultants (c) |
| _____ Insurance carriers (e)        | _____ Other _____             |

3. What safety and health related activities are performed by the top manager at your location?

| <u>Activities</u><br>(13-14) | <u>Time Spent in 1974</u><br>(15-18) |
|------------------------------|--------------------------------------|
| _____                        | _____                                |
| _____                        | _____                                |
| _____                        | _____                                |

How would you characterize the interest of the top manager in safety and health? (19)

|                         |                         |
|-------------------------|-------------------------|
| _____ Poor (a)          | _____ Above average (d) |
| _____ Below average (b) | _____ Excellent (e)     |
| _____ Average (c)       |                         |

4. How many safety and health personnel are in your organization?

| <u>Number of Full Time</u><br>(20-31) | <u>Job Titles</u><br>(32) | <u>Title of Person To Whom Reports</u><br>(33) | <u>Educational Level</u><br>(24) | <u>Approximate Annual Salary</u><br>(25-28) |
|---------------------------------------|---------------------------|--|----------------------------------|---|
| _____                                 | _____                     | _____  | _____                            | \$ _____                                    |
| _____                                 | _____                     | _____  | _____                            | _____                                       |
| _____                                 | _____                     | _____  | _____                            | _____                                       |
| _____                                 | _____                     | _____  | _____                            | _____                                       |

| <u>Number of Part Time</u><br>(30-31) | <u>Job Titles</u><br>(32) | <u>% of Time Spent on Safety and Health</u><br>(33-34) | <u>Title of Person to Whom Reports</u><br>(35) | <u>Educational Level</u><br>(36) | <u>Approximate Annual Salary</u><br>(37-41) |
|---------------------------------------|---------------------------|--|--|----------------------------------|---|
| _____                                 | _____                     | _____  | _____  | _____                            | \$ _____                                    |
| _____                                 | _____                     | _____  | _____  | _____                            | _____                                       |
| _____                                 | _____                     | _____  | _____  | _____                            | _____                                       |
| _____                                 | _____                     | _____  | _____  | _____                            | _____                                       |

5. Approximately how much time was spent orienting and training each new employee about safety and health in 1974?

(43-45) Time spent per employee \_\_\_\_\_  
 (44-47) Number of new employees in 1974 \_\_\_\_\_  
 (48-49) Job title of person(s) doing the training \_\_\_\_\_

6. What safety and health rules exist at your location? (50-62)  
 (Please check the appropriate responses)

|   |  |
|---|--|
| _____ None (a)  | _____ A few rules for specific jobs or work areas (a)        |
| _____ A few general rules in an employee handbook (a) | _____ Many rules for various specific jobs or work areas (a) |
| _____ Many general rules in an employee handbook (a)  | _____ Other _____ (f)  |

What was the estimated cost of preparing and distributing safety and health rules during 1974? (63-66)  
 \$ \_\_\_\_\_

7. What activities were performed during 1974 to maintain interest in safety and health?

| <u>Activity</u>                                 | <u>Cost During 1974</u> |
|---|-------------------------|
| _____ National or Regional Safety Contests (19) | \$ _____ (10-14)        |
| _____ Organization Devised Safety Contests (18) | _____ (15-20)           |
| _____ Safety publications (21)                  | _____ (21-26)           |
| _____ Safety posters (27)                       | _____ (27-32)           |
| _____ Other _____ (33)                          | _____ (33-38)           |
| _____ Other _____ (39)                          | _____ (40-44)           |
| _____ Other _____                               | _____                   |

8. How frequently during 1974 were safety meetings held and how long were they?

|                            | <u>Number<br/>During<br/>1974</u> | <u>Average<br/>Meeting<br/>Length</u> | <u>Number and<br/>Titles of<br/>People Involved</u> |
|----------------------------|-----------------------------------|---------------------------------------|---|
| Department or Employee     | (49-54)                           | (57)                                  | (48-50)   |
| Supervisory                | (51-53)                           | (53)                                  | (54-56)   |
| Management                 | (57-59)                           | (59)                                  | (60-62)   |
| Labor-Management Committee | (63-65)                           | (65)                                  | (66-68)   |
| (Other) (75) _____         | (69-70)                           | (71)                                  | (72-74)   |
| (Other) _____              | _____                             | _____                                 | _____   |

9. What other activities to train experienced employees occurred during 1974?

| <u>Activity</u><br>(76) | <u>Time<br/>Spent</u><br>(77-78) | <u>Number and<br/>Titles of<br/>People Involved</u><br>(79-80) |
|-------------------------|----------------------------------|--|
| _____                   | _____                            | _____  |
| _____                   | _____                            | _____  |
| _____                   | _____                            | _____  |

10. How frequently during 1974 were safety and health inspections conducted and by whom?

|                           | <u>How Many<br/>During 1974</u> | <u>Time<br/>Spent</u> | <u>Number of<br/>People Involved</u> |
|---------------------------|---------------------------------|-----------------------|--------------------------------------|
| Safety and health staff   | (8-10)                          | (11)                  | (12-13)                              |
| First line supervisors    | (14-18)                         | (18)                  | (17-18)                              |
| Other management          | (19-20)                         | (21)                  | (22-23)                              |
| Corporate or headquarters | (24-28)                         | (29)                  | (27-28)                              |
| Insurance carrier         | (29-30)                         | (31)                  | (32-33)                              |
| State or local government | (34-38)                         | (39)                  | (37-38)                              |
| Federal government        | (39-40)                         | (41)                  | (42-43)                              |
| (Other) (44) _____        | (49-50)                         | (51)                  | (48-49)                              |
| (Other) (50) _____        | (51-52)                         | (53)                  | (54-55)                              |

11. How much personal protective equipment was provided by the company during 1974?

|                             | <u>Number</u> | <u>Cost</u> |
|-----------------------------|---------------|-------------|
| Hard hats                   | (56-61)       |             |
| Prescription safety glasses | (62-63)       | \$ _____    |
| Plano safety glasses        | (64-69)       | _____       |
| Goggles                     | (70-73)       | _____       |
| Face shields                | (74-77)       | _____       |
| Respirators                 | (8-13)        | _____       |
| Safety shoes                | (13-18)       | _____       |
| Ear plugs                   | (17-20)       | _____       |
| Ear muffs                   | (21-24)       | _____       |
| Protective clothing         | (25-28)       | _____       |
| Gloves                      | (29-33)       | _____       |
| Gas Masks                   | (34-37)       | _____       |
| (Other) (38) _____          | (38-43)       | _____       |
| (Other) (43) _____          | (44-47)       | _____       |
| (Other) (48) _____          | (48-53)       | _____       |

12. How much money was spent during 1974 to correct unsafe physical conditions which could affect employee safety or health?

|                                   | <u>Cost During<br/>1974</u> |
|-----------------------------------|-----------------------------|
| Machine guarding                  | \$ _____                    |
| Walking and working surfaces      | _____                       |
| Materials handling                | _____                       |
| Electrical                        | _____                       |
| Health and environmental controls | _____                       |
| (Other) _____                     | _____                       |
| (Other) _____                     | _____                       |
| (Other) _____                     | _____                       |
| <b>TOTAL</b>                      | <u>_____</u><br>(52-55)     |

12. How would you compare the design and layout of your location to other similar operations? (s1)

\_\_\_\_\_ Poor (a) \_\_\_\_\_ Above average (a)  
 \_\_\_\_\_ Below average (a) \_\_\_\_\_ Excellent (a)  
 \_\_\_\_\_ Average (a)

How would you compare the housekeeping at your location to other similar operations? (s2)

\_\_\_\_\_ Poor (a) \_\_\_\_\_ Above average (a)  
 \_\_\_\_\_ Below average (a) \_\_\_\_\_ Excellent (a)  
 \_\_\_\_\_ Average (a)

14. How many physical examinations were provided by the organization during 1974?

|                   | Number  | Cost During 1974 |
|-------------------|---------|------------------|
| Pre-employment    | _____   | \$ _____         |
| Periodic          | 163-661 | 187-711          |
| (Other) (a) _____ | 173-741 | 178-781          |
|                   | 116-121 | 113-171          |

15. What facilities existed during 1974 to treat employee occupational injuries and illnesses?

|                           | Cost During 1974 |
|---------------------------|------------------|
| _____ None (1a)           | _____            |
| _____ First aid kits (1b) | \$ _____         |
| _____ First aid room (2a) | 116-341          |
| _____ Dispensary (31)     | 116-361          |
| _____ Hospital (32)       | 113-311          |
|                           | 113-421          |

Which employees treated employee occupational injuries and illnesses at your location during 1974?

| Number of People | Job Titles | Title of Person to Whom Reports | Percent of Time Spent | Approximate Annual Salary |
|------------------|------------|---------------------------------|-----------------------|---------------------------|
| (1a-1b)          | (2)        | (3)                             | (4-5)                 | (6-7)                     |
| _____            | _____      | _____                           | _____                 | _____                     |
| _____            | _____      | _____                           | _____                 | _____                     |
| _____            | _____      | _____                           | _____                 | _____                     |

16. What activities designed to reduce employee injuries away from work or off the job took place in 1974?

| Activity | Cost During 1974 |
|----------|------------------|
| (8-9)    | (10-11)          |
| _____    | \$ _____         |
| _____    | _____            |
| _____    | _____            |

17. What other occupational safety and health loss control activities took place in 1974?

| Activity | Cost During 1974 |
|----------|------------------|
| (12-13)  | (14-15)          |
| _____    | \$ _____         |
| _____    | _____            |
| _____    | _____            |

18. To what extent are records of occupational injuries and illnesses maintained?

|                                      | <u>Time Spent<br/>During 1974</u> | <u>Job Title of<br/>Person Involved</u> |
|--------------------------------------|-----------------------------------|---|
| _____ None (1)                       |                                   |   |
| _____ Lost work day injuries (10)    | <u>111-141</u>                    | <u>(19)</u>                             |
| _____ Doctor or medical cases (16)   | <u>117-201</u>                    | <u>(31)</u>                             |
| _____ First aid cases (22)           | <u>123-261</u>                    | <u>(37)</u>                             |
| _____ Investigation of injuries (28) | <u>129-321</u>                    | <u>(33)</u>                             |
| _____ Analysis of injuries (34)      | <u>135-361</u>                    | <u>(38)</u>                             |
| _____ Reports to management (40)     | <u>141-441</u>                    | <u>(48)</u>                             |
| _____ Reports to employees (46)      | <u>147-601</u>                    | <u>(81)</u>                             |

19. Which activities do you believe most effectively reduce occupational injuries and illnesses at your location?  
(Please rank all applicable activities)

- \_\_\_\_\_ Top management activities (51-64)
- \_\_\_\_\_ Safety and health staff activities (57-64)
- \_\_\_\_\_ Orientation and training of new employees (59-60)
- \_\_\_\_\_ Safety and health rules (61-62)
- \_\_\_\_\_ Safety publications (63-66)
- \_\_\_\_\_ Safety posters (67-68)
- \_\_\_\_\_ Safety meetings (69-70)
- \_\_\_\_\_ Training of experience employees (71-72)
- \_\_\_\_\_ Safety inspections (73-74)
- \_\_\_\_\_ Personal protective equipment (75-76)
- \_\_\_\_\_ Correction of unsafe physical conditions (77-78)
- \_\_\_\_\_ Physical examinations (79-80)
- \_\_\_\_\_ Injury treatment facilities (81-82)
- \_\_\_\_\_ Off the Job safety activities (111-112)
- \_\_\_\_\_ Records keeping (113-114)
- \_\_\_\_\_ Investigation of injuries and illnesses (115-116)
- \_\_\_\_\_ Analysis of injuries and illnesses (117-118)
- \_\_\_\_\_ Communication to employees about injuries and illnesses

20. What additional comments would you like to make? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

21. What was your occupational safety and health loss record during the past three years?

|   | <u>1974</u>    | <u>1973</u>    | <u>1972</u>    |
|---|----------------|----------------|----------------|
| Number of fatalities                          | <u>1181</u>    | <u>1261</u>    | <u>1271</u>    |
| Number of lost time injuries                  | <u>122-241</u> | <u>125-271</u> | <u>128-301</u> |
| Number of days lost                           | <u>131-341</u> | <u>134-381</u> | <u>138-421</u> |
| Number of medical cases                       | <u>135-381</u> | <u>142-431</u> | <u>148-511</u> |
| Number of first aid cases                     | <u>142-441</u> | <u>148-571</u> | <u>158-601</u> |
| Manhours worked                               | <u>151-671</u> | <u>160-741</u> | <u>170-801</u> |
| Injury frequency rate                         | <u>161-721</u> | <u>170-781</u> | <u>177-801</u> |
| Injury severity rate                          | <u>171-751</u> | <u>178-801</u> | <u>181-851</u> |
| Direct dollar cost of work injuries           | <u>181-801</u> | <u>181-851</u> | <u>185-901</u> |
| Indirect cost of work injuries (if available) |                |                |                |
| How was the indirect cost computed?           | _____          |                |                |

INFORMATION ABOUT THE ORGANIZATION

Name of organization \_\_\_\_\_

Address \_\_\_\_\_

Brief description of the operation \_\_\_\_\_

Age of the facility (51) \_\_\_\_\_

Name of Workmen's Compensation Insurance Company (52) \_\_\_\_\_

Name of labor union, if any (53) \_\_\_\_\_

Information about employees:

| <u>Type</u>                  | <u>Number</u>  | <u>Approximate Annual Income</u> |
|------------------------------|----------------|----------------------------------|
| Hourly employees             | 154,785        | 155,000                          |
| Clerical employees           | 151,521        | 152,477                          |
| First line supervisors       | 102,881        | 110,721                          |
| All other managers and staff | 175,781        | 177,911                          |
| <b>TOTAL</b>                 | <b>116,141</b> |                                  |

IDENTIFICATION

Name \_\_\_\_\_ Title \_\_\_\_\_

Date \_\_\_\_\_

Do you wish to receive a summary of the results of this survey? (16)  Yes (a)  No (b)

Safety Director:

Sometime ago, we sent you a questionnaire regarding Occupational Safety and Health Activities. Your response is urgently needed. Would you please take a few minutes to complete and return the questionnaire.

Thank you.

Foster C. Rinefort, Jr.  
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