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GENERALIZATION OF MEDICAL AND HEALTH COMPLIANCE RESEARCH TO COAL MINE SAFETY

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7. Author(s) H.P. Cole, P.K. Berger, T.F. Garrity, C.D. Auvenshine A.B. Szwilski, M. Hernandez, D.K. Blythe, W.E. Lacefield

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Methods for increasing compliance to medical and health regimens were reviewed along with similar research in industrial and mine safety. Principles abstracted from both areas suggest that compliance with health and safety practices is improved when: (1) Workers are cooperatively involved with management in setting safety goals and planning for their achievement, (2) the program has the support of workers, supervisors, and management, (3) specific tasks responsible for injuries are targeted, (4) company organizational policy, educational, and behavioral programs work together toward the same goals, (5) workers and supervisors are frequently informed about their degree of correct task performance, and (6) programs are monitored by the frequency of correct performance of targeted tasks, (the means to lowered accident rates) rather than by lowered accident and injury rates themselves (the goals for safety programs.) Safety programs that incorporate these principles increase persons' adherence to specified health and safety practices and subsequently decrease injury rates. It is recommended that: (1) a group of experts be convened to study the application of these principles to coal mine safety programs, and (2) a short course for safety trainers be developed to demonstrate how these principles can be used to strengthen existing mine safety programs.

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FOREWORD

This report was prepared by the Center for Professional Development, College of Education, and the Behavioral Research Aspects of Safety and Health (BRASH) working group of the Institute for Mining and Minerals Research (IMMR), University of Kentucky under USBM Contract Number PO333468. The contract was initiated under the Coal Mine Health and Safety Program. It was initiated under the technical direction of the Pittsburgh Research Center with R. Michael Digman and William J. Wiehagen acting as Technical Project Officers. Patrick J. Neary was the contract administrator for the Bureau of Mines. This report is a summary of the work recently completed as part of this contract during the period September 1, 1983 to September 3, 1984. This report was submitted by the authors on February 28, 1985.

PREFACE

Henry Cole, the project principal investigator, is a professor in the Department of Educational and Counseling Psychology, College of Education. Philip Berger is a professor in the Martin School of Public Administration, Graduate School. Thomas Garrity is a professor in the Department of Behavioral Sciences, Chandler Medical Center. Dwight Auvenshine is a professor in the Graduate Program in Rehabilitation Counseling, Graduate School, and in the Department of Educational and Counseling Psychology, College of Education. Anthony Szwilski is a professor in the Department of Mining Engineering, College of Engineering. During the project Maria Hernandez was a graduate student in the Department of Educational and Counseling Psychology, College of Education. David Blythe is a professor and Director of Continuing Education and Extension, College of Engineering. Warren E. Lacefield is a professor in the Department of Higher Education, and Director of the Office of Educational Research and Development, College of Education. Michael Digman and William Wiehagen, project officers from the United States Bureau of Mines, Pittsburgh Research Center, frequently met with the project team and provided valuable observations and suggestions.

Many other persons and agencies assisted the project team in completing this study. Any listing of names would likely omit individuals who contributed. Therefore, we gratefully acknowledge the assistance of these persons by listing the agencies with which they are affiliated. These include the University of Kentucky academic departments of the project team members, the Margaret I. King Library and its branch campus libraries, the University NASA Technology Applications Program; the Kentucky Department of Mines and Minerals; the West Virginia Department of Mines; The National Mine Health and Safety Academy; the Mine Safety and Health Administration; the Cincinnati National Institute for Occupational Safety and Health; the University of Kentucky Appalachian Studies Center; the Kentucky Joint Mine Safety Committee; the Kentucky Mining Institute; and the Collegiate Association for Mining Education. In addition, we gratefully acknowledge the competent assistance of Ms. Julia Fleming who prepared the manuscript using a word processing program, Mr. Robert Crovo who provided technical assistance with the IBM General Markup Language (GML) computer program used to assemble and print the document, and Ms. Shannon L. Price and Mr. Charles Vaught who assisted in proofreading the document.

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EXECUTIVE SUMMARY

A multidisciplinary team including behavioral scientists, health and safety specialists, and mining engineers reviewed research on how medical and health personnel attempt to increase the compliance of persons with recommended health and medical procedures. The team also looked for applications of similar behavior change strategies in underground coal mining, other mining, and other industries. Computer searches of 17 major data bases and professional networks of experts were used to compile a 31 page bibliography related to these topics. Common strategies that have been empirically determined to be effective in boosting persons' compliance with health and safety regimens were abstracted from this literature.

The chief findings are that compliance with recommended health and safety regimens is assisted by 1) fostering the informed consent and participation of the individual in diagnosing, setting, and working toward safety goals, 2) eliciting social support of peers, superiors, and managers for compliance with the prescribed safety practices, 3) targeting those specific tasks responsible for most injuries and clearly stating how these tasks should be performed safely, 4) using organizational, educational, and behavioral safety strategies in concert, 5) providing frequent cues and regular informational feedback to individual workers about the correctness of their performance of the targeted tasks, 6) tailoring the regimen to characteristics of the particular task and the individual worker's needs and abilities, and 7) monitoring the degree of compliance by focusing on frequency of correct performance of specified safety tasks (means to improved safety and health) as opposed to attending only to lowered accident and injury rates (goals for safety and health programs.)

Principles underlying successful programs that boost compliance with health and safety regimens were abstracted from the empirical literature. These principles were presented to a total of 85 coal mine safety experts who attended one of 4 regional meetings. Included in each group were union members and working coal miners; coal mine managers, supervisors, and safety directors; state and federal mine safety inspectors and instructors; and other persons connected with coal mine safety. These experts were generally supportive of the ideas, thought them to be practical, but expressed concerns and constructive ideas about such things as how to observe and monitor targeted safety behaviors in underground coal mining, and how to use records of percent correct performance of specific safety tasks by workers for informational feedback in a setting where such information might be seen as cause for citation by inspectors for anything less than 100% compliance.

Because the empirical research in related areas suggests the principles for boosting compliance with safety procedures would probably be effective in coal mines, and because the industry experts in the 4 workshops tended to agree with this assessment, two suggestions are made. The first is that a conference be arranged to include coal mine safety experts and key persons in health and safety compliance research. This group would further discuss and plan for the incorporation of the procedures identified in this study in coal mine safety programs. The second suggestion is that a short course be developed for coal mine safety trainers. The training would illustrate how the organizational, educational, and behavioral strategies reviewed in this report have been used to strengthen existing safety programs. Specifically, the course would be designed to assist coal company safety and occupational task trainers to apply the principles and strategies outlined in this report to their own local mine safety programs. It is suggested that the course be collaboratively planned and operated by state mining agencies, MSHA, the Bureau of Mines, and coal industry personnel. Short training programs using the course materials could promote the adoption of additional safety training methods not often used in the coal industry but known to be effective from studies carried out in other work places. Once incorporated with existing safety programs, these new techniques might increase rates of routine compliance of miners with safe work practices and subsequently lower accident rates, as has occurred in other work settings when these methods have been used.

CHAPTER 1: INTRODUCTION TO PROJECT GOALS AND ACTIVITIES

In medical and health research the term patient compliance (or adherence) refers to the degree to which a person follows recommended health or medical procedures (often called a regimen) designed to reduce risk of injury, illness, or death. Although it has generally not been used in the coal mine safety and industrial safety fields, the term "compliance" can be defined in a parallel manner as the degree to which a worker follows specific safety procedures designed to reduce injury, illness, or death. The purpose of this report is to explore the potential application of research in the medical and health compliance literature to boosting routine compliance of coal miners with recommended safety procedures.

Compliance Defined

In this paper the terms "compliance" or "adherence" mean simply the degree to which persons follow recommended health and safety procedures designed to lessen the frequency and severity of accidents, injuries, or illness. The terms are not used to mean legal compliance or to mean "submission to the will of others." Rather, the intention is to describe the frequency with which persons consistently follow a health or safety procedure. The procedure may be a prescribed medical regimen in a health setting, or it may be a prescribed safety practice in a work setting.

Project Goals

This report reviews selected empirical research results and theoretical models toward developing a more informed understanding of the individual adherence of miners to safety practices. The work reported was carried out by a multidisciplinary team of persons with expertise in the relevant areas. Specific goals of the project team included:

1. conducting a systematic search of the research in the medical, health, and primary prevention area on the topic of individual behavior, personal choice, and adherence to medical treatment regimens or primary prevention programs designed to reduce illness, accidents, and death;

2. determining to what degree similar research methods, procedures and findings have occurred in studies of individual miner behavior through a second search of the industrial and mine safety and health literature;

3. noting areas of similarity, omission, and possible application of methods, procedures, and theories between the two fields;

4. noting points of similarity and correspondence between successful approaches to boosting compliance in both the health and medical research and in the industrial and mine safety research;

5. presenting these observations to groups of experienced mine safety inspectors, analysts, and instructors to obtain their criticisms, insights, and suggestions;

6. using the information gathered from these criticisms of experienced professionals and from the study of the research literature to prepare a set of recommendations for mine safety education and research.

Changing Behavior and Life Styles to be Safer

There is a large body of research on changing persons' behaviors and life styles in the fields of medicine, health, and primary prevention. The research was stimulated by Public Health Service grants and other funds which became available after the Health Manpower Act of 1968 and the Comprehensive Health Manpower and Training Act of 1971 (Cole, 1978; Cooper, 1976). Much of this research focuses on changing patterns of individual behavior and personal choice in areas related to increasing adherence to health and/or safety practices in daily living (e.g., wearing seat belts, reducing smoking, taking medication for hypertension control, and modifying life style patterns of exercise and diet). Categories of accidents and injuries have observable behavioral and environmental factors associated with them. Research has shown that alteration of these behavioral and environmental factors can reduce the incidence of accidents and injuries (Benfari, Eaker, Stoll, 1981; Matarazzo, 1982).

Medical and health professions educational intervention programs designed to boost compliance have fallen into 4 general approaches (Benfari et al., 1981). These include:

1. interventions designed to modify individual physiological responses, such as relaxation training to reduce stress,

2. modification in the behavior of the health provider (dentist, nurse, physical therapist, physician, nutritionist, etc.) to make his or her teaching more understandable and acceptable to the client,

3. increasing frequency of patient routine adherence to specific prescribed medical regimen (diet, exercise, medication), and

4. modification of clusters of individual's behaviors or life style to reduce risk of injury or death associated with medical factors (heart disease, diabetes) or frequent accidents (highway, pedestrian, home, etc.).

The research in these areas may be relevant to thinking about individual coal miner adherence to safe work practices. For example, intervention programs that seek to lessen back and other skeletal muscular system injuries to miners through individual physiologic assessment and physical conditioning programs are examples of a physiological intervention. Safety programs that seek to improve the effectiveness of safety training staff, foremen, and management in communicating safety information, values, and policy to workers fall into the second category. Programs that seek to increase frequency of specific worker behaviors such as wearing safety glasses, always setting temporary roof supports before going past the last row of roof bolts, or always looking before backing equipment fall into the third category. Safety education programs designed to promote increased worker perception of hazards, ongoing corrective and preventive action to reduce risks, and the cooperative, vigilant, and consistent following of prescribed safe work practices fall under the fourth approach.

Acute versus Chronic Health and Safety Threats

The adherence literature in the medical and health fields can also be divided into programs for acute conditions, chronic conditions, and for primary prevention. The research indicates patient adherence to medical treatment of acute conditions does not generalize to adherence to chronic conditions where the immediate threat to life and health is not as pressing nor adherence as motivated by discomfort (Garrity, 1981; Taylor, Lichtman, & Wood, 1984). Adherence to safe individual miner work practices through daily making of personal choices probably more closely parallels the research on primary prevention of accidents and/or chronic diseases and risk factors.

The content of the Mine Safety and Health Administration (MSHA) modules on mine safety and health promote knowledge and skills whose routine practice is critical to individual and group safety. Yet, it is possible, and perhaps probable, that failure to exhibit such practices is only infrequently punished by a serious accident. In addition, retention of complex knowledge and skill which is not often used

or seen to be essential to daily work is often poor, as in retention of military skills like proper use of gas masks and first aid procedures (Hagman & Rose, 1983). These characteristics may conspire to make the daily performance of safe mining practices by individuals somewhat like the compliance of individual patients with regimens designed to prevent or lessen injury caused by chronic diseases like hypertension or diabetes. In both coal mine safety and these medical situations occasional non-compliance is statistically dangerous but often has no immediate punishing consequences and may even be immediately reinforcing by providing short cuts, saving time and effort.

Frequency of Compliance

Research results in medical compliance-adherence often show a U-shaped curve with approximately 1/3 of the trained population complying routinely, 1/3 occasionally complying, and the remaining 1/3 frequently not complying (Benfari, Baker, & Stoll, 1981). Although studies of this type appear to be absent from the mine safety and industrial safety literature, similar patterns may exist among individual miner behavior. If so, what is known in the medical health care literature about changing this distribution may be generalizable to the mine safety area.

Correlates of Compliance versus Intervention Studies

The most frequent studies of compliance in the medical and health research are correlational. Samples of persons who comply with a medical regimen, such as taking hypertension medication, and samples of persons who do not comply or partially comply are studied with respect to different types of characteristics. The intention of these studies is to determine the correlates of compliance, (e.g., the common characteristics which differentiate between persons who comply and those who do not comply.)

Characteristics of compliance and noncompliance that have been studied may be categorized into 6 areas. The first area includes studies of the characteristics of compliant patients and typically includes demographic and personality variables such as income level, educational level, intelligence, belief systems, and values. Characteristics of the patient's environment are a second focus. Here variables include the nature and extent of family support for, or opposition to, the regimen. A third area involves characteristics of the treatment regimen where variables such as the duration of treatment, its cost, and complexity are studied. A fourth area involves correlates of compliance

and the characteristics of the clinical routines. (e.g., how efficient, organized, and pleasant the clinical staff are in scheduling appointments, communicating information to, and providing treatment for patients.) A fifth area focuses on compliance and variables concerning patients' involvement in setting treatment goals, being informed about the problem and its treatment, and receiving and using information about the progress of the medical or health problem and its treatment. The sixth area concerns characteristics of the clinician-patient interaction and variables like the clinician's interpersonal style, verbal and non-verbal communication, and interpersonal dynamics are correlated with patients' compliance or non-compliance.

The majority of research studies in medical and health compliance are correlational. There are far fewer well-designed empirical intervention studies. Intervention studies are designed to manipulate one or more variables toward increasing frequency of compliance with a specific regimen such as a diet or exercise program.

Research in industrial safety and mine safety follows a similar pattern. There are many well-designed correlational studies in which characteristics of safe and unsafe work places have been identified. It is possible to cluster this research on correlates of safe work places into the same 6 categories that define the major studies in medical and health compliance. In addition, as is true for the medical/health field, there are few industrial safety and mine safety intervention studies and many correlational studies, several in underground coal mines.

One goal of the project team was to identify the well designed correlational studies in each field and to note possible points of similarity between correlates of compliance in each area. Another and more important goal was to identify the relatively few effective intervention studies in both fields and to attempt to extract from these a better understanding about common principles that may underlie interventions that are successful in boosting compliance, whether in the medical/health area or with industrial health and safety procedures.

Phases of Compliance

In both medical and health compliance and in industrial and mine safety, learning of recommended health and safety procedures is a complex social process. In both areas the learning appears to take place across a series of stages or phases. The content, methods of instruction, and conditions for learning the information, attitudes, and skills needed for consistent compliance vary across these phases.

One categorization of phases includes 4 stages: preparation, activation, tailoring, and sustenance (Garrity, 1983). In the first stage the patient or worker needs to become sensitized to the risks and develop knowledge and attitudes that support routine compliance. In the second stage the person must develop the motives and habits that lead to routine compliance with the procedure(s). In the third stage ways must be found to overcome barriers to routine compliance by changing the regimen to better meet the individual's characteristics (e.g., body size, strength, preferences, etc.). And in the fourth phase ways must be found to maintain high levels of routine compliance for long periods of time, often for the duration of ones life (as in control of diet and insulin in diabetes) or for the remainder of one's working life (as in coal mining and consistent adherence to standard safety procedures e.g., not going under unsupported roof or not working on live electrical circuits).

Another goal for the project team was to examine parallel ideas, strategies and research results about teaching and learning compliance with health and safety procedures across these or similar phases.

Strategies for Boosting Compliance

In both the medical and health compliance research and in the industrial and mine safety research, there appear to be 3 common strategies used to promote increased adherence to safe practices. These are organizational, educational, and behavioral strategies. In both areas organizational and educational strategies are rather common while behavioral strategies are far less frequent. It appears that all 3 strategies used in conjunction with one another may be potent in boosting persons' compliance with health and safety procedures.

Organizational Strategies: Organizational strategies for improving worker safety and health encompass a wide variety of management activities related to the planning and organization, and supervision of work. They include, but are not limited to implementing goals and policies designed to meet and exceed federal and state regulations; structuring the organization to give enhanced visibility, authority, and responsibility to safety and health concerns; allocating adequate resources to such safety-related programs as materials management, training, equipment maintenance; improving the interpersonal relationships among members of the organization; providing appropriate equipment to perform the work, etc.

Educational Strategies: Educational strategies include those training activities by which workers acquire new knowledge, skills, and attitudes. These strategies may involve job and task analyses to identify critical areas for training. Educational strategies are characterized by the application of the more traditional pedagogic methods such as classroom lectures, films, discussion groups, printed learning materials, self-instructional programmed learning modules, tutorial on-the-job training and the like. While the level of specificity of behavior and knowledge to be taught can vary from the highly specific to the highly general and abstract, educational programs are typically oriented toward the more generic end of the continuum. Specificity is usually defined in terms of local conditions (e.g., gaseous versus nongaseous mines, low versus high coal, and local equipment). Even where there is an analysis of accident data to identify problem behaviors, the methods of instruction tend to be traditional.

Behavioral Strategies: The term behavioral is used here in a methodological rather than a philosophical sense. Although much of the work in behavioral intervention strategies has grown out of the philosophical tradition of operant learning theory and American behaviorism, the methods of specification, observation, and measurement of behaviors instrumental to some longer term goal are wide-spread behavioral science methodologies used by researchers of many different philosophical bents. As will be illustrated later in this report, these behavioral methods are essential to and serve equally as well the cognitive psychology philosophical approaches to industrial safety (Cohen & Jensen, 1934; Latham & Yuki, 1975; Locke, 1980; Reber & Wallin, 1984) as they do the behavioral psychology philosophical approaches (Komaki et al. 1978, 1980, 1982; Rhoton, 1980).

Behavioral strategies focus on a limited number of skills and knowledge and utilize a variety of techniques to improve people's performance on those skills. Common to all these techniques is appropriately timed feedback or knowledge of results of the correctness of performance by the individual on the selected skills. The feedback data are gathered by direct observation of task performance in the actual work setting. Knowledge of results and feedback is not the same as the commonly used occasional rewards for low accident rates over a period of weeks or months provided by management; which is an organizational strategy. Feedback refers to the regular provision of information to workers and management about the adequacy of the workers' routine performance on a small number of selected behaviors (whose correct performance should produce an eventual reduction in accidents of a certain type). When behavioral strategies are used in concert with organizational and educational strat-

egies, they have the potential to greatly increase the routine compliance rates of individuals with prescribed health and safety practices, and thus to achieve long term health and safety goals.

Another goal of the research team was to explore these 3 strategies, their interaction, and to identify studies that incorporated each approach. The ways in which the 3 approaches logically support one another and the contributions of each strategy to increased compliance with health and safety procedures are of particular interest.

Engineering, Enforcement, and Education

It is generally agreed that improved mine safety requires a 3-pronged approach. First, many of the hazards of coal mining have been and can continue to be engineered out of the work place by the proper design of equipment and operations. Examples include canopies over equipment that have saved the lives of over 200 miners in the last few years.(1) Another example is the automated temporary roof support system (ATRS) now available on roof bolting machines, and required by the state of West Virginia.

Enforcement of mine safety laws, regulations, and procedures is also important. It is generally agreed that enforcement is required to promote and maintain safe working environments. The research that supports this position has been clear for many years and established across many nations (Committee on Underground Coal Mine Safety, 1982; Teleky, 1948).

Yet, neither engineering nor enforcement activities alone are sufficient. In addition, management and workers must be educated to the hazards of the work place, the worth of safety procedures, and the benefits of compliance with these safe work practices. The report has little to say about engineering or enforcement. While the project team recognizes the critical nature of each approach, this research is focused on "education."

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(1) Address by David Zegeer, Director, Mine Safety and Health Administration, to the 3rd Annual Joint Mine Health and Safety Conference, May 29-30, 1984 at the National Mine Health and Safety Academy, Beckley, West Virginia.

Justification for this Study

Much of the improvement in mine safety is based on legislation, enforcement of these laws, and improved technology (Committee on Underground Coal Mine Safety, 1982). Human factors research and ergonomics has also produced a safer work place (Bockosh, Peay, & Wiehagen, 1982). Less attention appears to have been devoted to the theory, research, and practice of individual miner compliance or adherence to safe practice. Yet, it is generally argued that individual miner adherence to safety practices is important if the frequency of disabling accidents and injuries is to be reduced (Committee on Underground Coal Mine Safety, 1982). Indeed, this is a basic assumption underlying mine safety and health training programs.

The findings from the present study may suggest new areas of research and development for mine safety education. First, the results may assist thinking about performance standards and criteria for individual miner adherence to safety practices. Second, the findings may help inform the development of mine safety training materials and programs. And third, the activities and products of this study may widen the network of professional researchers and methods involved in the conceptualization of mine safety research, training, and development. These potential outcomes are consistent with recommendations made from a recent study of mine safety training (Digman & Grasso, 1981).

Secondary Goals and Benefits

In addition to the obvious benefits of generalizing research findings from one area of human behavior to another in order to improve health and safety of miners, it was anticipated that other benefits might be realized from the project activity. Primary among these was the possibility of increased contact among persons in the mining industry, MSHA and state regulatory agencies, researchers from various organizations, and University of Kentucky academics from several departments and fields. The project has led to increased contact and collaboration among these groups on this and other projects.

Conclusion

This chapter provides an overview to the project goals and activities. Subsequent chapters provide details of the project activities, findings, reflections, and recommendations. Chapter 2 describes the research methods and procedures used to carry out the work. Chapter 3 provides a

review of the main findings in medical and health compliance research arranged in 3 broad areas. The first area is concerned with factors that are correlated with high levels of persons' compliance. The second area describes 4 phases involved in learning to comply routinely with a health or safety procedure. The third area describes 3 strategies used to increase the compliance of people with recommended health and safety regimens. A fourth topic that runs throughout this chapter concerns the health and safety beliefs and values people have and how these influence their compliance behavior.

The next 4 chapters deal with each of these topics in this same sequence as these medical and health research results also apply to compliance with safe work practices in industrial and mine work settings. Taken together, chapters 3 through 7 provide the essential common findings of many empirical studies of human compliance with health and safety regimens. In chapters 4 through 7 many of these findings are explained and illustrated by using examples from coal mining. Chapter 8 provides a summary of the reactions of 4 groups of experienced coal mine industry personnel to some of the project's major findings. Chapter 9 calls attention to important questions and issues raised by the project findings. It concludes with suggestions for additional research and training activities concerned with increasing individual worker compliance with safety practices.

CHAPTER 2: RESEARCH PROCEDURES

The main purpose of this project is to review the theoretical and empirical research in medical and health compliance with the intention of extending knowledge from this field to improved compliance of coal miners with safe work practices. To accomplish this goal a number of major activities were undertaken. These activities include:

1. assembling a multidisciplinary research team such that each member had expertise in some key aspect of the project (e.g., mine safety, industrial health and safety, mining engineering, medical and health compliance, human behavior, instruction and learning, behavior change, perception of hazards, etc.).

2. establishing a biweekly seminar for the project team where each person could identify relevant ideas, methods, research, and external experts related to the project topics and goals, and where team members could teach and inform each other;

3. planning and carrying out, with the assistance of information specialists and librarians, computerized searches of many large data bases that contain abstracts of the world's published research on topics related to the project goals;

4. gathering, organizing, discussing, and summarizing the information gained from activities 2 and 3;

5. presenting a summary of some of this information to groups of coal industry experts to seek out their criticisms, suggestions, elaborations, and ideas;

6. synthesizing the results of this activity into a document that call attention to possible extensions of medical and health compliance research and methods, and effective industrial safety programs toward improved mine safety education and training, and that raise questions and suggest areas for future research.

This chapter informs the reader about the sources and methods used by the project team to arrive at the synthesis. The synthesis itself appears later in chapters 4-7, and is the main result of the project activity.

The literature search and analysis was a key part of the project activity. Summaries of the search strategies provide information about the frequency and characteristics of published research on topics related to the project. This section may be useful to others who wish to carry out similar studies in the future.

The Project Team and Seminar

The project team consisted of five core persons, all faculty members in different academic units at the University of Kentucky. This core group was assisted by two other faculty members and one graduate student. In addition, many other experts and specialists assisted the core group throughout the project.

One member of the core group is an educational psychologist with a specialty in applied learning theory and the design of instruction, especially in technical fields for adult learning. He and two of the other project members had recently completed a book under an NSF contract concerned with assessing learning of complex skills in continuing education courses for scientists and engineers (Cole, Moss, Gohs, Lacefield, Barfield, & Blythe, 1984).

A second member of the team is a medical sociologist. He has a research specialization in medical and health compliance. He has recently served as a proposal reviewer, consultant, and member of the working group on patient compliance for the National Heart, Lung, and Blood Institute of the National High Blood Pressure Education Research Program. Two of his recent papers (Garrity, 1981, 1983) that summarize aspects of medical and health compliance work were used to introduce other project members to this area.

A third team member is an experimental psychologist who has completed post doctoral study in health care services and industrial health and safety. His research and teaching are in the areas of health care administration, work and health, research methods and health program evaluation, and the social psychological aspects of preventive medicine. During the course of the project Dr. Berger was also on sabbatical leave as a researcher with the Applied Psychology and Ergonomics Branch of NIOSH in Cincinnati. He was able to draw upon the resources of this group to assist with the present project.

A fourth member of the team is a professional mining engineer, registered in Kentucky, Alberta, Canada, and Great Britain. He is an experienced coal miner and is a certified underground and surface mine manager. He has been involved in mining, mine management, engineering, and research in several countries in Europe, North and South America, and Africa. He has taught courses for coal industry personnel on mining engineering, mine management, and mine safety. Dr. Szwilski has expertise in the area of physical factors involved in safe mining practices and has applied this knowledge to improve both safety and productivity in coal mines in Kentucky and elsewhere.

A fifth member of the team is a counseling psychologist and a rehabilitation psychologist. He recently co-authored a book on counseling in the health and human services (Auvenshine & Noffsinger, 1984). He has served as a consultant to Job Corps, the Social Security Administration, several state rehabilitation and disability determination agencies, and provided consultation with private clients in rehabilitation, career planning, and employability status. Dr. Auvenshine has direct knowledge of the outcomes of industrial and coal mine accidents and in addition has an interest in counseling and teaching for health preservation and accident prevention.

This core group was assisted by the College of Engineering, Director of Continuing Education and Extension. This individual has extensive contacts in the mining industry. He assisted the project members in establishing contacts with relevant persons and resources. With his assistance, the project team met with many experts in various aspects of mine safety including authors of the National Academy of Science Toward Safer Underground Coal Mines (1982), the superintendent and staff of the National Academy for Mine Health and Safety, officials from the Kentucky Department of Mines and Minerals, the Kentucky Mining Institute, the Kentucky Joint Mine Safety Committee, the Collegiate Association for Mining Education, safety directors, miners and management from a number of coal companies, and others. Dean Blythe also attended many of the team seminars and provided valuable technical and practical information related to his expertise as an engineer and continuing education specialist.

Another person who assisted the project is a master's degree level counseling psychologist with previous experience as both a general psychology practitioner and a librarian. Ms. Hernandez' skills in these areas were used to locate and organize the materials gathered in the computer searches. Other librarians and information specialists in four University of Kentucky libraries and librarians at the National Mine Health and Safety Academy and the Cincinnati National Institute for Occupational Safety and Health also regularly assisted the project team in locating and gathering materials.

Three of the project team members traveled to the National Mine Health and Safety Academy on 4 occasions. During these 4, two-day visits, Academy librarians, mine safety instructors, and others assisted in locating relevant research, planning and carrying out computer searches of specific data bases, and obtaining important documents and publications.

As the project team planned its work, located and read materials, interviewed experts, made field trips, etc., the biweekly seminars continued as a means to synthesize the information and ideas encountered. Notes and records of these sessions served as the basis for this and other technical reports and papers developed by the project effort.

Search Strategies and Methods

Four approaches were used to search out and identify relevant prior research in both medical and health compliance and in industrial and mine safety. The first approach was based upon the expertise of the project team members and their individual network of professional contacts. Each team member was asked to be alert for and to nominate published research that related to the project topic. A second approach was to plan and carry out machine searches of computerized data bases of published research. A third strategy was to identify additional relevant research from citations in worthy studies identified in the first two approaches. A fourth approach enlisted the assistance of many persons from outside the project for nominating appropriate studies, technical reports, persons, and research articles that might prove useful. The four approaches often were redundant in their independent identification of key studies and reports. Yet this strategy also revealed unique studies that might have been overlooked had only one approach been used.

The most fruitful approaches to locating relevant research were the expertise and the professional networks of the project team members and the computer searches of the data bases. The meetings with industry experts were also helpful but usually resulted in nominations of studies identified by the other approaches, and fewer sources were identified by this means than by the other approaches.

In the early phases of the project team seminars, Professor Garrity provided an overview of the research findings in medical and health compliance. The intention was to identify common characteristics of successful compliance interventions. Other team members discussed the possible extension of these ideas to industrial and coal mine safety. Team members were alerted to locate any studies that dealt with concepts of adherence and compliance and industrial and mine safety. It was later determined there is little research that combines these two areas.

Computer Searches of Data Bases

Seventeen major data bases were machine searched by strategies tailored to the project goals and the particular data base characteristics and structure. The first data base searched was Index Medicus. A description of this activity illustrates how similar searches were carried out across the other data bases. Appendix A describes each data base searched. Table 1 lists the data bases searched plus additional information about the results of the machine searches. Index Medicus was searched through the MEDLINE database which is derived from the National Library of Medicine's Medical Literature Analysis and Retrieval System (MEDLARS). The MEDLINE computerized data base was accessed through a commercial firm, Bibliographic Retrieval Service Incorporated, Latham, New York, via terminal at the University of Kentucky Medical Center Library.

To prepare the strategy for the computer search, two of the project team members and the project graduate assistant spent several hours each doing a manual search of Index Medicus, reviewing the system thesaurus, and becoming familiar with the relevant descriptors for the topics of interest given the project goals. In addition, a medical library specialist expert in computer searches of MEDLINE assisted the group.

The manual searches had determined there were few or no articles dealing with adherence-compliance behavior and coal mining. While many articles on coal mining were located, nearly all dealt with respiratory disease and health topics. This knowledge was used to broaden the search strategy to include other industrial and occupational settings where research on adherence-compliance behavior and safety might exist. The intention was to identify studies in the data base from 1979 to 1983, inclusive, that dealt with behavioral factors in industrial accidents, especially coal mining. Two search sets relevant to industrial accidents were chosen: occupational accidents and accident prevention crossed with industry. Five sets relevant to human behavior were selected: "accident proneness", "cooperative behavior," "patient compliance," "risk taking" and "group processes." The term "patient compliance" was used because the Index Medicus thesaurus specifically defines behavioral compliance in this manner. "Compliance" alone is defined as a medical term concerning the elasticity of the chest and rib cage. There is no "adherence" term in the system. All of the terms used in the search described in Table 2 are specific Index Medicus descriptors. Articles included in the system are coded by these descriptors. The search in the data base was by these coded terms.

Table 1: Results of data base searches

Database	Time Period	No. Items Identified	No. Relevant Items	No. Foreign Language Items	No. English Foreign Items	No. U.S. Items	No. Items Obtained & Studied
ABI/INFORM	71-21/1/83	12	6	0	0	6	3
Coal Data Base	78-1/24/84	44	6	0	1	5	5
COMPENDEX	70-11/1/83	38	10	0	2	8	7
DOE ENERGY	74-11/1/83	138	41	15	5	21	14
ERIC	66-12/20/83	8	4	0	0	4	4
HSELINE	77-12/5/83	5	3	2	0	1	1
INDEX MEDICUS 1st (Industrial Safety)*	79-11/5/83	199	19	1	4	6	16
INDEX MEDICUS 2nd (Med. Compliance)*	79-11/28/83	21	21	0	1	20	19
LABORDOC	65-12/5/83	19	8	5	3	0	0
MINTEC	68-1/20/84	24	12	0	7	5	4
NIOSHTIC (coal mine)	37-12/23/83	161	34	4	2	28	15
NTIS 1st (narrow)*	64-12/1/83	4	4	0	0	4	4
NTIS 2nd (broad)*	64-4/17/84	197	25	0	0	25	18
PSYCHINFO 1st (narrow)*	67-12/1/83	6	5	0	0	5	6
PSYCHINFO 2nd (broad)*	67-12/7/83	22	11	1	3	7	8
PSYCHINFO 3d (broader)*	67-12/14/83	174	39	3	2	34	26

Table 1: (continued) Other data base searches with poor results

Database	Time Period	No. Items Identified	No. Relevant Items	No. Foreign Language Items	No. English Foreign Items	No. U.S. Items	No. Items Obtained & Studied
GEOARCHIVE	74-12/5/83	0	0	0	0	0	0
GEOREF	61-12/5/83	0	0	0	0	0	0
Management Contents	74-12/5/83	6	1	0	0	6	1
Sociological Abstracts	63-12/5/83	3	0	0	0	0	0
Social SCISEARCH	72-12/5/83	0	0	0	0	0	0
Totals		1,081	249	31	30	185	151

*The first search of INDEX MEDICUS was specifically planned to identify mine safety and industrial safety research concerned with worker behavior. The second search was designed to locate major reviews of the recent research on medical and health compliance.

The first NTIS search was planned to yield only articles directly relevant to the project. It located 4, all relevant. Because the NTIS data base had other relevant research not related to coal mining the second search included other mining and related industrial work places concerned with safety behavior. It yielded more hits but only about one in 8 was relevant. A similar 3 part search was used for similar reasons with PSYCHINFO and it produced similar results.

The values in this table are approximate and not always exact. For example, many of the documents located in the searches were large technical reports and proceedings. Often these documents contained several relevant articles. The values reported in this table are the numbers of hits obtained using the name of the article or publication identified in the abstract called by the searches. In addition the same document is sometimes indexed and identified in more than one database. Thus, the values reported in the total row are both larger by virtue of multiple article sources and smaller by redundantly identified sources.

In the machine search each industrial accident set was crossed with each human behavior set. The actual search strategy and the numbers of articles located in each category follow. The search sets and their various combinations were designed to identify any existing studies in the data base concerned with adherence/compliance and cooperative behavior and coal and other mine safety. Because there is little about coal mines or other mines in the data base, the broader sets of industrial/occupational safety and accident prevention were included. It was hoped that relevant studies in industrial settings similar to mines might be identified. Sets including terms like "accident proneness" and "labor unions" were included to identify studies related to specific areas of interest given the project goals. For example, we wondered to what degree union-related studies or interventions in accident prevention programs and occupational safety might appear in the literature. The methodology terms like "longitudinal studies," "epidemiological studies," and "population surveillance" were included and crossed with "occupational accidents" and "accident prevention" to identify any appropriate empirical studies of populations of workers and miners at risk for injuries.

The results were both disappointing and informative. Review of the 199 abstracts obtained revealed only 19 to be relevant to the project goals. Examination of Table 2 and the actual abstracts reveals that studies in industrial safety and human compliance behavior are not reported for coal mining, mining generally, or in industrial safety. It became apparent that the Index Medicus was not a particularly good data base for the types of studies of most interest to the project team.

A second search of Index Medicus was later undertaken to update the team's knowledge of advances in medical and health compliance. The search was planned to identify comprehensive review and synthesis articles more recent than the sources already known to the project team. This second search proved fruitful, identifying some additional 21 studies, all of which were relevant. Nineteen of these were actually located and studied.

Similar search strategies were planned for the other data bases shown in Table 1. Each data base was selected in consultation with librarians and information specialists in the appropriate technical field, after an explanation of the project goals by project team members. In each case characteristics of the data bases and the thesaurus of descriptors were reviewed in order to develop a relevant search strategy, one that would be sensitive to the structure and language of each data base, and also one that would meet the project needs.

Table 2: Strategy and results for index medicus machine search 1979-1983

Search Set Number	Search Terms and Yield
1	Occupational accidents (955) X Accident Proneness (49) = 5 articles in both categories
2	Occupational Accidents X Cooperative Behavior (2670) = 0
3	Occupational Accidents X Patient Compliance (2473) = 0
4	Occupational Accidents X Risk Taking (96) = 0
5	Occupational Accidents X Group Processes (4057) = 6
6	/Accident Prevention (1422) X Industry (6557)/ (59) X Accident Proneness = 0
7	Accident Prevention X Industry X Cooperation Behavior = 1
8	Accident Prevention X Industry X Patient Compliance = 1
9	Accident Prevention X Industry X Risk Taking = 0
10	Accident Prevention X Industry X Group Processes = 2
11	Accident Prevention X Occupational Accidents = 85
12	Coal Mining (412)
13	/Mining - Coal Mining/ (511)

Sets 11 and 12 were crossed individually with sets 1 through 11. All crosses yielded no articles except for one article identified in search set number 14.

14	Occupational Accidents X Accident Proneness X Mining = 1

In addition to these sortings on critical content areas, three sets dealing with methodological approaches were examined: epidemiological studies, longitudinal studies and population surveillance. Each of these was crossed with the two industrial accident sets.

Table 2: (Continued)

Search Set Number	Search Terms and Yield
15	Epidemiological studies (37,415) X Occupational Accidents (955) = 35
16	Longitudinal studies (33,662) X Occupational Accidents = 29
17	Epidemiological studies X Accident Prevention (1422) = 18
19	Population surveillance X Occupational Accidents = 0
20	Population surveillance X Accident Prevention = 2
	Finally, a set dealing with labor unions was crossed with the industrial accident sets.
21	Labor unions (870) X Occupational Accidents = 7
22	Labor unions X Accident prevention = 10

Instructions were given to delete foreign language articles. A total of 199 citations were identified. Examination of the abstracts revealed only 19 that were relevant to the project goals. Of these, 16 were located, duplicated, and studied.

In all cases, where the data base permitted, a free word search of the abstracts and titles was used as opposed to a search restricted to only categorical descriptors assigned by the abstractor. The Index Medicus files could not be searched by a free word strategy because of properties of the data base. Generally, free word searches of the abstracts and title contents are more likely to pick up irrelevant articles, but this approach is more inclusive than a search restricted to only the formal descriptors used to index the article.

Relatively early in the project a general search strategy was developed. This general strategy was used as it is presented in Table 3 to search the NIOSHTIC data base maintained by the National Institute for Occupational Safety and Health. For other data bases this general search strategy was used to plan individual searches tailored to each data base. Searches were often carried out two or three times on each data base and adjusted each time until they worked well. Actual search strategies used for other data bases are included in Appendix B. Examination of the strategies provides information about the number of articles in each data base for each descriptive term used. Examination of Table 1 reveals which data bases were most productive for purposes of this project.

An independent search of 10 of the 17 data bases was conducted by Mr. Steve Hoyle of the National Mine Health and Safety Academy. The purpose of the project activity was explained to Mr. Hoyle. He then developed the search strategy shown in Table 4. He used this same strategy across all 10 data bases. His search was also a free text search of the abstract and title. Inspection of Table 4 reveals information about the frequency of various topics of interest to this project that appear in these data bases. Sets 10, 13, and 14 are of most interest to this project. Four data bases in this group produced no entries dealing with coal, mine?, occupational, and safe?.(2) Others provided few articles of interest. COMPENDEX and NTIS were the most productive. These same findings are supported by the results of the independent and more finely tuned searches reported in Table 1.

There are other important differences between the yields of the data bases that are not reflected in the simple frequencies in Table 4 or in Table 1. For example, if the terms "behav?" or "attitud?" had been included in the strategy in Table 4, the COMPENDEX and NTIS frequencies for

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(2) The question mark is a truncation system designed to locate any suffix with the root word, (e.g., mine, miner, mines or safe, safety, safer.)

Table 3: General Machine Search Strategy

The intention is to identify studies concerned with coal mining and coal miners and accident and injury prevention especially through the changing of worker attitudes and behavior.

The strategy that has seemed to be most effective thus far is to produce 5 sets as follows.

Set 1 coal (w) mine?*

Set 2 accident? or accident (w) prevention or safety or injury? or hazard?

Set 3 attitud? or behav? or human (w) factor? or personnel (w) training

Set 4 mining or mine?

Set 5 industrial or occupational or work (w) place or workplace or factory or factories or plant?

Sets are combined as follows.

Set 1, set 2, and set 3 to yield studies directly related to coal mining and safety, accident prevention, etc.

Set 4, set 2, and set 3 to yield studies directly related to mining of any type and safety, accident prevention, miner behavior, etc.

Set 5, set 2, and set 3 to yield studies related to industrial and occupational safety in a variety of workplaces and safety, accident prevention, worker behavior, attitudes, etc.

The first search using sets 1, 2, and 3 should result in the most appropriate and smallest number of articles.

The second search using sets 4, 2, and 3 is more inclusive because it incorporates all mining related articles.

The third search is the broadest of all since set 5, 2, and 3 should include all related articles in any occupational or industrial setting.

Delete all hits included in the first search when calling for the printing of the hits from the second search and call for deletions of all hits in the first two searches when printing the hits from the last search. This ensures given abstracts will not be repeated across the three searches.

A free word search of the abstracts is the approach judged most appropriate by librarians and informations specialists in each of several fields because it rules out inaccurate coding by abstractors with standard descriptors, and because it is more sensitive to relevant articles, although it also produces more irrelevant material.

*The question mark is a truncation symbol. It locates all common variations of the root word. Behav? was used to include the American and British spellings of the root word and its common variants.

sets 10, 13, and 14 would have been much lower. Inspection of abstracts in these data bases gathered in the individual searches shown in Table 1 reveal that technical data bases like DOE, NTIS, and COMPENDEX deal with the physical and ergonomic aspects of safety and health as opposed to behavioral science aspects. At the same time a data base like PSYCHINFO (Psychological Abstracts) has very little information on coal or coal mine safety. Yet, these few articles tend to be more relevant because they deal with attitudinal and behavioral aspects of safety. In addition, there is more research on industrial and occupational safety in the PSYCHINFO data base and many of these non-mining articles proved to be particularly relevant.

When the term "behavior" is used in data bases like COMPENDEX or DOE it often refers to the behavior of machines, structural materials, electrical circuits, or aspects of the mine physical environment (e.g., rock mechanics, ground stability and control). Differences in terminology across fields makes searches of multiple data bases for a core of similar research studies difficult, and it requires the expertise of specialty librarians and information science professionals who are familiar with each area.

Limitations of the Searches

The searches cannot be said to have been exhaustive. However, they can be said to be thorough. It is likely that relevant research was identified by the four general and somewhat redundant search approaches described earlier. Yet, it is possible that relevant articles in the data bases and others not in these data bases may have been overlooked. For example, the general search strategy described in Table 3 was used with NIOSHTIC. Crossing sets 1, 2, and 3 (the most relevant set concerned with coal mining) produced 161 hits. Examination of these abstracts revealed that 34 were directly relevant to the project. Of these, 28 were of United States origin. Yet, the project team was able to obtain only 14 of the actual documents. Many of the documents in systems like NIOSHTIC or NTIS are difficult to obtain. Some are very long technical reports, costly to reproduce. Some few are working copies and are marked "best available copy" on microfiche and are sometimes difficult or impossible to read completely.

A second search of the NIOSHTIC data base by crossing sets 2, 3, and 4 minus the yield from the first search produced another 227 hits all related to mining other than coal mining. A third search crossing sets 2, 3, and 5 produced another 406 hits. This last search produced articles related to accidents, injuries, hazards, prevention, attitude,

Table 4: Frequencies of relevant articles by search terms across 10 computerized data bases

Search Strategy		Computerized Data Bases				
Set Number	Set Term(s)	ABI/INFORM	COMPENDEX	ERIC	GEOARCHIVES	GEOREF
1	Coal	1,865	24,009	320	14,644	17,514
2	Mine?	1,374	33,878	674	78,632	164,242
3	Safe?	6,605	22,273	6,007	701	992
4	Accident	1,059	8,370	878	19	66
5	Industrial	13,320	39,830	9,956	1,575	3,753
6	Occupational	2,315	1,400	18,719	16	4
7 (1*2)	Coal * Mine?	360	8,726	66	3,212	4,861
8 (4*5)	Accident * Industrial	150	729	101	0	0
9 (4*6)	Accident * Occupational	125	237	106	0	0
10 (7*3)	Coal * Mine? * Safe?	54	898	9	42	44
11 (5*3)	Industrial * Safe?	745	1,819	652	3	13
12 (6*3)	Occupational * Safe?	1,019	486	852	7	0
13 (7*11)	Coal * Mine? * Industrial * Safe?	6	40	1	0	0
14 (7*12)	Coal * Mine? * Occupational * Safety	13	44	2	0	0

* = and

? = truncation symbol to pick up variations of the root word

Table 4 (Continued)

Search Strategy		Computerized Data Bases				
Set Number	Set Term(s)	Management Contents	NTIS	PSYCHINFO	Social SCISEARCH	Sociological Abstracts
1	Coal	1,116	21,589	46	975	166
2	Mine?	755	33,505	218	2,200	351
3	Safe?	2,854	65,566	2,300	3,251	681
4	Accident	343	8,785	978	619	193
5	Industrial	10,622	184,905	3,967	7,990	8,765
6	Occupational	861	10,611	11,362	3,226	4,464
7 (1*2)	Coal * Mine?	181	6,244	24	149	73
8 (4*5)	Accident * Industrial	57	4,175	104	10	31
9 (4*6)	Accident * Occupational	42	502	47	7	9
10 (7*3)	Coal * Mine? * Safe?	12	1,212	4	24	4
11 (5*3)	Industrial * Safe?	372	29,045	110	43	74
12 (6*3)	Occupational * Safe?	430	6,280	123	239	39
13 (7*11)	Coal * Mine? * Industrial * Safe?	5	568	2	0	3
14 (7*12)	Coal * Mine? * Occupational * Safety	1	183	3	0	0

* = and

? = truncation symbol to pick up variations of the root word. (Improper truncation of terms is fraught with potential difficulty. For example "Set" 11 Industrial * Safe? Produced not only the expected "industrial safety" articles but also called forth articles dealing with "industrial safes." Means to avoid these difficulties exist.)

behavior, human factors, training, industrial, occupational, work place, factory and plant. Examination of these 633 additional abstracts revealed only a few relevant articles that were not previously identified from the other searches. However, approximately 30 additional abstracts that are tangentially relevant to the project were identified.

In summary, the combined four approaches to identification of relevant research included identification of appropriate articles and studies by the project team and their professional network, computer searches of major data bases, identification of additional articles from citations in relevant articles gathered in the first two steps, and nomination of relevant studies and articles by many coal industry and safety experts over the course of the project. Collectively, these activities resulted in the 28 pages of references listed at the end of this report. Approximately one-third of these were identified by the computer searches and the other two-thirds mainly by the professional expertise and network of the project team, and from citations in relevant articles identified earlier. Nominations of key articles and studies by coal industry and safety experts were, with a few exceptions, redundant with these other sources. Especially strong studies were generally redundantly identified by multiple computer searches, the project team and its professional network, and citations in many articles.

Properties of The Safety Literature Identified

The literature identified in the searchers varied greatly in its quality and character. The project team was most interested in empirical research on effective means for promoting compliance with health and medical regimens. Most of the major findings in this area were known to members of the project team prior to the search activity because of their prior personal research activity in the area. Some additional empirical research was identified in this area through the second computer searcher of Index Medicus, but the newer research added little to the major synthesis of this area by Haynes, Sackett, & Taylor (1979). There also tends to be a relatively large amount of empirical research in medical and health compliance, although sample sizes tend to be small, and treatment durations relatively short.

The project team learned quickly that the theory and techniques of medical compliance had not been generalized to industrial and mine safety. Therefore, a primary interest was the identification of industrial and mine safety intervention and training programs that provided empirical evidence for their effectiveness. The intention was to determine if effective techniques for increasing worker

compliance in safety practices were similar to effective tactics for boosting medical and health regimen compliance. If so, a set of general principles might be inferred.

As the materials identified in the searches were gathered and studied several things became apparent. First, there were few empirical studies of industrial or mine safety interventions. Second, most of the articles identified spoke in general terms of the need to promote safety, described safety laws and rules and the promulgation of these, and provided descriptions of safety programs without providing empirical evidence of the program effectiveness. Third, other articles dealt with theories of accidents, injuries, "proneness," hazard perception, risk, risk analysis, etc. These theoretical articles were often well written and quite useful to the project goals, as will be seen in Chapters 4, 5,and 6, but they are not empirical studies. Fourth, the well-designed and well-controlled empirical studies of safety interventions tended to be carried out in factories and other work places and not in mines. Fifth, the most effective safety intervention studies tended to augment traditional safety education and training methods with behavioral methods including targeting, operationally defining, observing, measuring, and providing frequent feedback to employees and supervisors about their daily performance of specific work practices in safe and unsafe ways. Sixth, the largest group of empirical studies of industrial and mine safety are descriptive and correlational rather than interventive and casual in their design.

Categories of The Empirical Safety Literature

Table 5 summarizes the main categories of empirical studies identified in the industrial and mine safety area. It also specifies some categories in which studies are possible but were not identified by our search strategies. Of the millions of article abstracts in the data bases searched, only a few fit within these categories, primarily because there are so few published empirical studies in relation to other types of articles in the areas of interest in this study. Table 6 provides a listing of the major empirical studies identified in each category. These studies were particularly useful as the basis for the synthesis presented in Chapter 4.

It should be noted that the project team was not seeking to locate and review operant learning and/or behavior modification interventions in the work place or organizational development approaches. There are many of these, but they tend to deal with topics like production efficiency, human relations, and communication. Safety is a focus that is

much less prominent in this large literature (Prue & Bacon, 1978). The main criterion for the identification and review of the empirical studies in this project was that they must deal with a safety intervention with some degree of demonstrated success. Tables 5 and 6 simply report the type of approach most frequently used in these empirical studies. It should be noted that, in general, we have not included automobile driving operant theory interventions with private citizens.

Nomination of Relevant Studies by Industry Experts

Three primary means were used to solicit nominations of relevant research by industry experts. Early and mid-way through the project, descriptions of the project goals and activities were published in two news letters that have wide circulation in the coal industry. Readers were invited to contribute information and ideas to the project team and several did so. The two news letters used were the Scoop published by the Kentucky Department of Mines and Minerals and the CINK Newsletter published by the Coal Information Network of Kentucky.

A second method was to solicit information about relevant studies from the many experts with whom the project team was in steady and frequent contact, primarily personnel in the Kentucky Department of Mines and Minerals, The National Mine Health and Safety Academy, the Cincinnati NIOSH Center, the Pittsburgh and Spokane Bureau of Mines Centers, the Health and Safety Analysis Center in Denver, the MSHA Arlington Office, the Kentucky Joint Mine Safety Committee, The Kentucky Mining Institute, and a number of persons in coal companies.

A third method was to solicit information about relevant research from the 85 coal industry experts who attended the 4 project seminars at each of 3 regional and one national meetings. More will be said about this in Chapter 6.

Conclusion

This chapter has described the methods employed by the project team. The logical analysis and inferences developed in Chapter 4 are grounded in these methods. Before proceeding to Chapter 4 it is important to present the basic outline of the empirical findings in medical and health compliance. Armed with the information in this chapter and Chapter 3, the reader should be able to comprehend and evaluate the merit of Chapter 4, the center piece of the study.

Table 5: Categories of empirical studies in industrial and mine safety

1 Descriptive--Correlational studies of safe and unsafe work environments

- 1.1 Coal mines, underground
- 1.2 Other mines
- 1.3 Other industrial settings

2 Causative-interventive studies in which independent variables identified in correlational and descriptive studies (or other variables) are manipulated as treatment variables in safety programs toward changing frequencies of accidents and injuries (dependent variables)

- 2.1 Narrow focus behavior modification studies targeted toward one specific task, problem, or skill (e.g., wearing safety glasses, using hearing protectors, locking out power sources, etc.)
  - 2.1.1 Coal mines underground
  - 2.1.2 Other mines
  - 2.1.3 Other industrial settings
  - 2.1.4 Personal private sector (e.g., teaching safe street crossing to one's children)
- 2.2 Broad focus behavioral specific studies concerned with increasing persons' compliance with clusters of targeted skills or tasks and/or which tend to promote increased hazard detection and preventive action
  - 2.2.1 Coal mines, underground
  - 2.2.2 Other mines
  - 2.2.3 Other industrial settings
  - 2.2.4 Personal private sector settings (e.g., teaching defensive driving tactics)
- 2.3 Organizational development, management-worker training, sociotechnical systems approaches designed to increase communication, promote safety values and goals, and to foster norms and skills of safe performance
  - 2.3.1 Coal mines, underground
  - 2.3.2 Other mines
  - 2.3.3 Other industrial settings

Table 6: Examples of empirical safety studies by major categories

1 Descriptive Correlational Studies

1.1 Coal Mines, Underground

Althouse, R., & Hurrell, J.J. Jr., (1977). An analysis of job stress in coal mining. Cincinnati: National Institute for Occupational Safety and Health. PB 274-796.

Committee on Underground Coal Mine Safety. (1982). Toward Safer Underground Coal Mines. Washington, D.C.: National Academy Press.

Committee on Underground Coal Mine Safety, Commission on Engineering and Technical Systems (1983). Fatalities in Small Underground Coal Mines. National Research Council, Pittsburgh: Bureau of Mines. OFR 124-83.

Davis, R.T., & Stahl, R.W. (1964). Safety organization and activities of award-winning companies in the coal-mining industry. Pittsburgh: Bureau of Mines, IC 8224.

DeMichiei, J.M., Langton, K.A., & Wiles, T.C. (1982). Factors associated with disabling injuries in underground coal mines. Arlington, VA: Mine Safety and Health Administration.

Naval Ammunition Depot, Research and Development Department (1971). Survey of Human Factors in Underground Bituminous Coal Mining. Craine, IN: Department of the Navy, Ordinance System Command, RDTR No. 184.

Pfeifer, C.M. Jr., Stefanski, J.L., & Grether, C.B. (1976). Psychological, behavioral, and organizational factors affecting coal miner safety and health. Columbus, MD: Westinghouse Behavioral Service Center, National Institute for Occupational Safety and Health, Contract No. HSM 99-72-151.

Sanders, M.S., Patterson, T.V., & Peay, J.M. (1976). The effect of organizational climate and policy on coal mine safety. Crane, IN: Naval Weapons Support Center, Applied Sciences Department, Bureau of Mines, Contract No. H0242039.

1.2 Other Mines

(no studies identified)

Table 6 (Continued)

1.3 Other Industrial Settings

Cleveland, R., Cohen, H.H., Smith, M.J., & Cohen, A. (1979). Safety program practices in record-holding plants. Morgantown, WV: National Institute for Occupational Safety and Health.

Cohen, A. (1977). Factors in successful occupational safety programs. Journal of Safety Research, 9 (4), 168-176.

Simonds, R.H., & Shafai-Sahrai, Y. (1977). Factors apparently affecting injury frequency in eleven matched pairs of companies. Journal of Safety Research, 9 (3), 120-127.

Smith, M.J., Cohen, H.H., Cohen, A., & Cleveland, R.J. (1978). Characteristics of successful safety programs. Journal of Safety Research, 10 (1), 5-15.

2 Causative Interventive Studies

2.1 Narrow Focus Single Task Behavior Modification

2.1.1 Coal Mines, Underground

(no studies identified)

2.1.2 Other Mines

(no studies identified)

2.1.3 Other Industrial Settings

Cohen, A. (1976). The influence of a company hearing conservation program on extra-auditory problems in workers. Journal of Safety Research, 8 (4), 146-162.

Smith, M.J., Anger, W.K., & Uslan, S.S. (1978). Behavioral modification applied to occupational safety. Journal of Safety Research, 10 (2), 87-88.

Zohar, D. (1980). Promoting the use of personal protective equipment by behavior modification techniques. Journal of Safety Research, 12 (2), 78-85.

2.1.4 Personal Private Sector

Lewin, G.B., & Halvia, Y. (1970). The influence of advisory letters in changing the driving behavior of private motorists in Israel. Accident Analysis and Prevention, 2, 189-198.

Lewin, G.B., Haliva, Y., & Tel-Nir, N. The influence of personal communication on the driving behavior of private motorists in Israel. Accident Analysis and Prevention, 4, 269-300.

Table 6 (Continued)

2.2 Broad Focus Multiple Behavioral Skills

2.2.1 Coal Mines, Underground

Rhoton, W.W. (1980). A procedure to improve compliance with coal mine safety regulations. Journal of Organizational Behavior Management, 2 (4), 243-249.

2.2.2 Other Mines

Uslan, S.S., Adelman, H.M., & Keller, R.S. (1978). Testing the effects of applied behavioral analysis and applied behavioral management techniques on the safe behaviors of salt mine personnel. Pittsburgh: Bureau of Mines (Contract No. JO166137)

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(no studies identified)

* All 3 articles deal with aspects of the same experiment

** Both articles deal with the same experiment

CHAPTER 3: SUMMARY OF MEDICAL-HEALTH COMPLIANCE RESEARCH

Knowledge of health and illness is far enough advanced that recommendations can be made to patients about things they can do to prevent illness and to bring some extant illnesses under control. In many instances confidence in the efficacy of these recommendations must be tempered by the realization that even the best advice is often disregarded by patients. The level of patient noncompliance has been estimated to range from 20 to 80 percent of patients (Dunbar & Stunkard, 1979), and average 50 percent of those on long-term regimens (Sackett & Snow, 1979).(3)

Research on medical compliance gained momentum in the early 1960s. At that time non-compliance was viewed as a problem in the patient --the patient's failure to carry out physician recommendations. From this perspective, the task of the compliance researcher was to uncover reasons for this failure in the patient's knowledge, attitudes and behaviors. As explained below this tack yielded little in the way of consistent findings, especially in regard to factors that were susceptible to change and remedial manipulation. Subsequently, compliance investigators broadened their focus and began to examine characteristics of the patient's environment, of the clinical routine, of the recommended regimen and, finally characteristics of the clinician-patient interaction itself. The latter cluster of factors is clearly the most difficult one to study; the interaction process is complex and dynamic. However, it may actually be the most promising target for interventions to improve medical compliance. The most recent additions to the medical compliance literature are studies that evaluate interventions strategies designed to boost patient compliance.

In this chapter a brief summary of the fruits of medical compliance research is presented. It begins with an enumeration of factors found associated with patient adherence to preventive and therapeutic recommendations. There follows a presentation of promising methods for teaching patients to follow-through with clinical advice. The latter is organized around the notion that the clinician's teaching task differs at various stages in the patient's learning to become complaint with a long-term preventive or therapeutic regimen. A third section reviews how organizational, educational, and behavioral strategies are used to increase compliance of patients with medical regimens. Each strategy is

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(3) Portions of this chapter are adapted from an earlier chapter on dental compliance with the permission of the American Dental Association. See Garrity (1983) in the references for the complete earlier article.

defined in Chapter 1. Here, more detail is provided about each strategy and the effectiveness and interrelationships among the three are discussed. Finally, the health belief model is discussed in a number of places throughout this chapter because it helps to explain how persons' perceptions, attitudes, and values influence compliance and noncompliance behavior.

Each of the next 4 chapter addresses these same 4 topics and in the same order, but with respect to compliance with safe work practices by miners and other workers. One chapter is devoted to each topic. Thus, the present chapter sets forth the basic structure for organizing the research results reviewed in the next 4 chapters.

Correlates of Compliance

This brief review of the literature on factors that appear to be associated with patient compliance has benefited from several previously published works which should be consulted for more detailed treatment of this area (Dunbar & Stunkard, 1979; Sackett & Snow, 1979; and Haynes, Taylor, & Sackett, 1979). For convenience these factors are divided into 5 groups: characteristics of the patient, of his environment, of the recommended regimen, of the clinical routines in the setting within which he or she receives care and, finally, characteristics of the clinician-patient interaction. It must be understood that statements regarding what is or is not a correlate of compliance are at best, only tentative truths. In this area of research every rule has its exceptions. Factors that correlate consistently in treatment of one illness, or in patients with one sort of social characteristic may be unrelated under other circumstances.

Patient Characteristics: An impressive number of studies examining the influence of sociodemographic characteristics of patients on compliance have been reported, especially in the early literature. Although lower social class, education, occupation and income have in many studies been found correlated with lower compliance, there are also numerous studies in which no link is apparent. The same inconsistency is evident in studies of age, marital status, sex and race as correlates of good compliance (Haynes et al. 1979).

Studies of the standard personality traits of patients have failed to provide consistent correlates of compliance. However, certain measures of patient attitudes, perceptions and action predispositions seem to hold more promise (Haynes et al. 1979). There are indications that the personal inclination to perform health-promoting actions is found in

superior compliers (Becker & Maiman, 1975). Such people are not only more likely to follow a specific therapeutic recommendation but other pro-health advice as well. They are more likely to have regular health checkups, keep and use a variety of dental and medical health aids around the house, and keep medical appointments reliably (Antonovsky & Kats, 1970; Becker, Drachman, & Kirscht, 1972).

The health belief model which has excited both interest and controversy among health behavioral researchers points to another area of cognitions that has promise for understanding compliance (Becker, 1974). In its purest form this paradigm views patient decisions to comply as the product of perceptions about personal susceptibility to the negative health states that flow from noncompliance and perceptions about the severity of the health and behavioral problems that would result from the noncompliance. In addition, the patient's decision about compliance is also seen as resulting from perceptions about the benefits and cost involved in taking the recommended action. As might be expected, the model predicts that the greatest probability of adherence is found in those with the perceptions that they are susceptible to the disease, that the disease is severe and that the recommended regimen is effective in preventing or treating the disease but not very costly in the effort and expense required for carrying it out. Interest in this conceptualization has spawned numerous tests of its ability to predict compliance. Haynes and associates (1979), found that the majority of these efforts confirmed the influence of these variables, although the relationships are modest (r values range from approximately 0.25 to 0.60). However, the model is by no means without its critics (Weisenberg, Kegeles, & Lund, 1980).(4)

Finally, patient knowledge has been examined from several perspectives as a factor in patient compliance. Patient intelligence, though associated with compliance in a few studies, is not generally considered a reliable correlate (Haynes, Taylor, & Sackett, 1979). Similarly, patient knowledge of the disease is not correlated with compliance behavior (Sackett et al., 1975). Patient knowledge of the preventive or therapeutic regimen itself, however, seems to be a consistent predictor of patient adherence (Dickey, Mattar, & Chudzek, 1975).

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(4) A subsequent chapter explores the health belief model and similar expectancy value models in terms of their possible explanatory utility for thinking about worker adherence to safety practices

Characteristics of the Patient's Environment: No aspect of the patient's milieu has been found more consistently to promote patient compliance than the influence of the patient's family (Dunbar & Stunkard, 1979). This influence might involve the subtle pressure to conform to family expectations that the regimen ought to be followed. It might also spring from the sort of understanding and sympathy that tells the patient that the regimen, though onerous, is important for continued well-being. The family may also provide practical or material support: reminders that it is time to carry out the recommended behavior, help with the purchase and preparation of foods required by the regimen and the like. Though it is not clear from the literature, it might be expected that well informed non-family friends and co-workers might also provide social and emotional encouragement for the patient to follow the regimen (Alderman & Schoenbaum, 1975).

Characteristics of the Regimen: Four aspects of the recommended regimen may influence levels of compliance. Duration of the regimen is negatively associated with compliance (Haynes, 1979a). The passage of time appears to lessen the intensity of motivation to follow recommendations, although it may also be true that after a certain period of good compliance, many people would form a habit that incorporates the behavior into everyday life style. Complexity of the regimen also promotes noncompliance. Complexity is increased when the number of different actions and medications or doses of medication are increased (Haynes, 1979a). Intrusiveness of the regimen into daily activity patterns also affects adherence; the less disruptive the regimen the better the patient's follow-through (Dunbar & Stunkard, 1979). Finally, although some would not agree (Haynes, 1979a), the number and intensity of side effects of the regimen may be negatively associated with patient adherence (Dunbar & Stunkard, 1979; Haynes, 1979a). Blackwell (1973), concludes that side effects of medications that are "unexpected" and "alarming" have the greatest likelihood of damaging compliance.

Clinic Routines: Although there is relatively little research on features of clinic routines and their impact on compliance, there is some indication that long waits for attention in the clinic or office are linked to poor compliance. Haynes suggests that waiting time is increased by block scheduling, clinician lateness, patient lateness and patient no-shows (Haynes, 1979a). Dunbar and Stunkard (1979) point out that the poorer compliance usually found in public clinic settings as compared with private practices may be accounted for not only by the greater waiting time but also by lack of continuity of care (e.g., not being followed by the same clinician from visit to visit) and by lack of personalized care (Dunbar & Stunkard, 1979).

Aspects of Clinician-Patient Interaction: Garrity (1981), reviewed literature bearing on aspects of the clinician-patient relationship that appear to influence patient compliance in a variety of clinical settings. Four categories of factors are identified: (1) the teaching style of the clinician, (2) the match of expectations between clinician and patient, (3) the locus of responsibility in the provider-patient dyad and (4) the affective tone of the relationship.

As mentioned above, there is evidence that good patient understanding and knowledge of the therapeutic regimen is associated with better compliance. This finding implies the need to examine variations in the clinician's skills as a teacher. Ley and his co-workers (1976), have found that compliance benefits from regimen teaching that uses logical organization, repetition, emphasis on the importance of follow through, simple language and specific behavioral recommendations. They also found that understandability of a patient pamphlet boosted both recall and compliance with the booklet's recommendations (Ley et al. 1976).

Svarstad (1974) made direct observations of physician-patient interactions and found better compliance among patients with whom the doctors had been most explicit. The researcher's index of explicitness included factors such as clear mention of length of time a drug should be taken, dosage, regularity and purpose of the drug. Written instructions for patients were weighted more heavily by the researcher in the explicitness index. Svarstad (1974) also found that the clinicians being studied differed consistently with respect to their usual levels of explicitness; but it was also learned that the more questions asked by patients, the more explicit the instruction they received.

The second aspect of the clinician-patient interaction that influences compliance level is the extent to which the expectations of the two are in accord. For example, if the patient expects the clinician to spend time answering questions but the clinician neither expects nor does this, then some discord, even if unexpressed, is likely. This discord may result in open quarreling, feelings of dissatisfaction and failure to follow through on the practitioner's advice. Although there are a few studies that support this sort of dynamic (Caine & Wijesinghe, 1976; Francis, Korsch, & Morris, 1969), and authorities who view it as a very powerful model for understanding compliance (Kasl, 1975), more information is needed bearing on the independent predictiveness of mutual expectations.

A third aspect of the clinician-patient relationship that may enhance compliance entails the balance of the responsi-

bility between provider and patient. There is now reason to believe that when the patient's role is defined as being an active collaborator with the clinician the likelihood of good patient compliance is increased. Several studies tried different approaches to this very objective. Several have engaged the patient in "negotiations" with the clinician with regard to compliance and other treatment goals and procedures; enhanced compliance has resulted (Eisenthal, Emery, Lazare, & Udin, 1979; Tracy, 1977). Research on attempts at "patient activation" are still relatively few and recent. Two imaginative approaches to boosting the patient's sense of responsibility for self-care have been the involvement of the patient in authorship of the medical record with the physician (Fishbach, Sionelo-Bayog, Needle, & Delbanco, 1980), and stimulation of patient questioning of the physician by inviting the patients to formulate questions immediately before being seen by the doctor (Roter, 1977).

The fourth aspect of the clinician-patient relationship that appears to influence patient compliance is the affective tone of the relationship. This aspect is similar to what others call social or emotional support (Dimsdale, Eckenrode, Haggerty, & Kaplan, 1979; Levy, 1980); it regards the presence or absence of sympathy, understanding and encouragement in the clinician-patient interaction. Svarstad's (1974) work again provides pertinent data. She developed an index of clinician approachability. The clinician's index was raised if he or she solicited patient questions, did not "clock-watch" and did not mumble or cut patients off in response to their questions. Further, clinicians who greeted the patient, responded to his or her first question, smiled or laughed with the patient and bid farewell to the patient on closing the interaction were given points that raised the approachability index. Finally, when the clinician made an unexpected departure from the interaction, what Svarstad (1974) termed a "quick getaway," a deduction from the approachability index was made. These characteristics were measured by direct observation of the interaction. The investigator found considerable variation in the approachability of the eight physicians in the study. This measure of approachability, an amalgamation of signs of friendliness, interest, and respect for the patient, was found to be directly associated with level of patient compliance.

In the pediatric medical setting, Freemon and colleagues (1971) found the affective tone of the relationship between physician and parent of the young patient consistently associated with compliance. The greater the friendliness and solidarity expressed toward the parent by the doctor, the better the compliance. Conversely, the more disagreement, tension and antagonism evidenced by the physician the poorer the patient's follow-through.

To this point we have reviewed, albeit briefly and selectively, the literature on correlates of compliance. This information helps inform following discussion of promising approaches for improving compliance.

Phases of Compliance

Learning occurs in a progressive manner beginning with the introduction of the value, concept, or behavior to be learned and proceeding to its internalization. Internalization has occurred when the taught value becomes the value of the learner and the concept or behavior becomes an intrinsic, almost taken-for-granted component of the learner's intellectual or behavioral repertory.

The first stage of compliance with the recommended practice involves preparation of the patient for maintenance or restoration of health. The first stage lays a foundation on which teaching, practice, and motivation for adopting the recommended behavior is constructed. It involves introducing the patient to an area of information that is logically important for understanding the justification of the subsequent recommendations.

The second stage attempts to activate the patient. In this stage, a patient who is prepared with appropriate background knowledge is moved from a state of passivity with respect to the prescribed behavior to activity.

The third stage involves tailoring the regimen for optimal fit with the constraints of the patient's individual life situation. This process of finding a best fit occurs gradually as a variety of approaches are tried in order to make the regimen a comfortable part of one's everyday routine. The result of this process of adjustment should be the internalization of the prescribed practice such that failure to perform would create inner tension only relieved by performance of the adopted behaviors. When this occurs a pro-health habit has been inculcated.

The fourth stage promotes the sustenance of the new habits in ways that confirm and support their continuance. In comparison with the previous stages, this one should require fewer and less intense efforts to discharge.

As we move from stage to stage of the compliance process, suggestions for interventions will be presented. All are implied by research on correlates of compliance reviewed above, and most have already been tested in one or more health settings and found to be effective.

Preparation: The first phase provides basic information for the patient to understand the relevance of the regimen and his or her susceptibility to the problem and its potential severity. Specifically the patient needs to know how the disease progresses and what the consequences are. Great detail and long presentations of this information is not appropriate and may be counter productive. What is more effective is a short but clear and accurate description of the problem and the procedure for its control or prevention (Garrity, 1983).

In light of the findings that biological information on disease pathogenesis is not associated with compliance outcomes, it is important to realize that exquisite detail and lengthy presentation of this information is not efficient. Rather, this sort of technical information merely sets the stage and provides justification for the more crucial information coming in the next phase of the process. Nonetheless, even this background biological information must be presented in a logical way, in words and at a level that can easily be grasped by the patient and with any graphic teaching aids that facilitate the process.

It is in this first stage that the patient's perception of the seriousness of the disease outcomes might best be influenced, one aspect of the health belief model described earlier. Some clinicians have attempted to heighten this perception by using relatively dramatic photographs or films of disease-devastated organs or patients. These approaches often make an impression but they may also backfire if patients become so threatened that defensive denial drives them away from medical care altogether or into the irrational stance that this could not happen to them. Strong fear-arousing stimuli must be used selectively.

The outcome of this first or preparatory stage may well be a patient with knowledge and appreciation of the dangers of the target disease and its link to non-compliance. However, it is clear that this general knowledge will not be translated into personal behavior or motivation to act preventively unless it becomes seen as a problem with relevance to this patient.

Activation: The second or activation stage involves convincing patients that they must be actively involved in and responsible for the health or medical regimen. Techniques useful for boosting compliance include presenting evidence that the patient is susceptible to the problem (e.g., gum disease by plotting bleeding points), "behavioral assignments," "negotiation," and "contracting." Behavioral assignments require that the patient record baseline frequencies of compliance and noncompliance with the prescribed

regimen, say flossing teeth. These data indicate to the patient and clinician something of the frequency of compliance. Negotiating and contracting involve the clinician and patient in discussing the advantages and disadvantages of following the regimen and discussing the immediate and long-term costs and benefits, such as are involved in a diet or exercise regimen. Contracting is often geared toward striking an agreement between the health provider and the patient such that the duties for each in the regimen are clearly specified, including rewards and penalties for each party. If properly implemented, stage two should move the patient from an informed but uninvolved status to one of being motivated to act and convinced of the need for taking personal responsibility for one's own health. The first logical step in this activation stage appears to be the demonstration to the patient that the health changes already identified are currently or potentially present in his own body. In health belief model terms, the patient needs to appreciate his own susceptibility.

Because the patient for the first time is aware that the disease is or soon may be present in his own body, he is able to consider which, if any, of his values are thereby threatened; they might include aesthetic values and appearance, or economic values and the cost of extensive future treatment, or physical comfort values and the threat of painful disease endpoints, or others. These thoughts relate to perception of seriousness in health belief model terms and can be heightened by the clinician-teacher.

So far in stage two we have emphasized interventions, predicated on the health belief model, that are calculated to activate the patient, to move the patient from awareness of illness theory to awareness of the danger of disease in himself or herself. This perception of one's own susceptibility was then complemented by heightening perception of the values that are threatened by this disease process. The patient should now be motivated to learn what can be done about this.

Awareness of the specifics of the regimen is known to be a consistent correlate of compliance. Both knowledge of the regimen and compliance with it are associated with the quality of teaching. The above-described studies of Ley (1976, 1982), and Svarstad (1974), portray good teaching as: (1) giving specific advice, (2) emphasizing the importance of the advice, (3) employing simple words and sentences, (4) arranging advice in categories with the most important advice early, and (5) using repetition. Opportunities for patients to ask questions and demonstrate skills and understanding should also be part of the process. "Tests" of patient skills and knowledge ought to be given in subsequent

appointments and continued practitioner interest demonstrated.

Patient activation involves convincing the patient that taking responsibility for self-care is crucial and expected. Patient involvement may be furthered in ways beyond simple statements of its importance. Behavioral assignments, a kind of patient homework, have been found to be practical in boosting patient activation (Shelton & Levy, 1981). For example, the patient can initially be asked to complete a diary in which are recorded the times and places in which different regimen behaviors were attempted, along with difficulties that arose in those instances. Not only is the diary a useful source of information about barriers to compliance and hence a basis for later tailoring of the regimen, it also indicates to the patient the clinician's desire and need to have patient involvement.

Two other techniques for boosting patient activation are "negotiation" and "contracting." Both involve the clinician and patient in discussion about the pros and cons of compliance and, to a certain extent, bargaining about the costs and benefits of following the clinician's advice. While the negotiation process can vary greatly in length and detail, the implication for the patient is that the clinician wants to share responsibility with the patient and treat the patient like a responsible partner in the process of care. Contracting adds to the negotiation process the completion of an explicit agreement about the reciprocal responsibilities of the two parties. Sometimes the agreement is fairly formal, executed and signed on a document developed in advance for recording the individual agreement reached by the parties. Occasionally, the contract specifies rewards and penalties for fulfilled and broken agreements. Results of these techniques have been remarkably good (Eisenthal et al., 1979; Tracy, 1977; and Steckel & Swain, 1977). They may achieve their benefits by causing the patients to exercise responsibility (Schulman, 1979), or learn what is recommended to a greater degree in the process of negotiation. Or these techniques may work because of the interest shown by or the reward anticipated from the clinician. Whatever the mechanism, patient involvement is undoubtedly enhanced.

Tailoring: The third stage of compliance is devoted to tailoring or adjusting the prescribed regimen to the individual's circumstances so that the procedure will become habitual. For example, if the regimen is flossing of teeth to prevent gum disease, the patient may encounter difficulties in trying to carry out the procedure. The dental floss may break or become stuck between teeth with tight contact points. The original recommendation about the time of day

for flossing may be inconvenient or embarrassing to the patient. These and other barriers to the regimen can be identified by the patient. The health practitioner and the patient can plan to overcome the barriers. For example, the dentist can smooth tooth surfaces and lessen the tension at the tight contact points, thus preventing the floss from breaking and sticking. The dentist can reassure the patient of the value of flossing at other times and not necessarily immediately after each meal. Family members of the patient may ridicule the flossing activity, thinking it to be silly or a waste of time. Pamphlets provided by the dentist or her visits with family members may provide information that will increase family member support for the regimen. Follow-up visits by the patient to the clinician during which compliance with the regimen is monitored is important because it provides the clinician with information about further tailoring of the prescribed regimen to make it more efficient and routine. It also provides an opportunity for feedback to the patient on the rate of correct performance of the regimen. In addition, there is opportunity for social reinforcement, praise, and encouragement of the patient's efforts by the clinician. The regular and correct implementation of the regimen by the patient can also be directly reinforcing because the person knows he or she is taking positive and effective steps toward maintaining the health of teeth and gums. Charting of bleeding points of the gums can produce objective data that show both patient and clinician the effectiveness of the corrective and preventive flossing regimen. Feedback of this type coupled with tailoring activities has been shown to increase compliance rates (Haynes et al., 1979; Garrity, 1983). If the primary task of stage two was moving patients from receptive passivity to action, the primary task of stage 3 is tailoring the prescribed actions of the patients to help them to become a comfortable and more or less habitual part of their daily routines. It is at this stage of the compliance process that the health belief model again becomes relevant. Here the purpose would be to diminish the patient's perception of costs involved in following recommendations. Perhaps with the help of the patient's diary or reports, the clinician could begin to point to ways in which the perceived barriers could be lowered.

We know from the earlier review of correlates of compliance that regimens that are complex, long-term, and disruptive of daily routines and fraught with distressing side effects are unlikely to be followed with perseverance. Aggressive attempts to lessen such difficulties would appear to be critical for patient continuation with the regimen.

Follow-up appointments that focus on patient progress in execution of the regimen are important in the stage of tai-

loring. At these visits negotiation continues in which patient difficulties are identified in the patient's own words and provisions for adjustments are made. The clinician gets new insights about what additional teaching is required and makes additional suggestions as he learns from patient reports, observation of patient skill, and the patient's clinical status. Through follow-up visits there is assessment of the patient's successive approximations of goal behaviors. Each patient has a unique constellation of problems with any complex regimen; these can only be addressed by an individualized approach. This sort of persistent review of patient progress delivers the message to the patient that the clinician is interested in and convinced of the importance of what the patient is attempting.

At this stage the patient is struggling to carry out behaviors that are still strange, perhaps difficult and often unrewarding in themselves. Motivation to persist often comes from extrinsic rewards such as the praise and approval of the clinician and the family. Until performance of regimen behaviors becomes habitual, extrinsic rewards are important. Identification of rewards is a challenge to one's creativity. One funded study that attempted to induce compliance with antihypertensive regimens, rewarded fulfilled behavioral contracts with lottery tickets (Steckel & Swain, 1977). Self-rewards may also provide an avenue attractive for some patients.

Family praise and approval for the complying patient is an approach to enhancing compliance that appears quite effective (Levy, 1980). The other side of the coin is family disapproval when the regimen is not followed. Such "social support" maneuvers are now quite prevalent as devices not only for enhancing adjustment to the new compliance regimen but also for other difficult adjustments in the health arena; we need only think of weight reduction groups, problem-drinking groups, smoking cessation groups and the like (Kanzler, Jaffe, & Zeidenberg, 1976). A few studies have demonstrated the clinician's interest in the patient and concern about compliance by arranging for home visits by home health workers of various kinds (Wilber & Barrow, 1969).

Sustenance: The fourth stage is concerned with sustaining the regimen indefinitely at high rates of compliance. It assumes the person has already adopted the regimen as part of his or her habitual daily activity. There is a tendency for some health practitioners to see this stage as the end point where little or no further involvement of the clinician is required. However, research suggests that a substantial proportion of successful life style changes revert to preintervention rates (Stuart, 1980). Although there are

few studies on sustenance of long term compliance reported in the health and medical literature, some generalizations may be stated. The materials, routines, and social structures that support compliance need to continue to be available. In the case of flossing teeth, the dental floss must continue to be available, social support by the family members for the activity continues to be important, and changes in life style and daily routines may interfere with the compliance routine. Intermittent reinforcement of the compliance behavior needs to occur. Visits between the clinician and the patient need to continue during which patient performance is monitored. Objective data such as bleeding points and pocket depths of gum lesions need to be measured and charted. These current data can be compared with pretreatment data, and earlier treatment data to provide objective feedback to the patient and clinician about functional rates of compliance. Clinician praise, social reinforcement, expressed concern for the patient's health, and suggestions for dealing with barriers which may arise for the patient remain important. Although the long-term effects of a regimen are beneficial and tangible, the immediate positive effects of compliance are minimal and the immediate effects of the procedure remain bothersome and require extra effort. In some cases, such as flossing, more immediate outcomes, such as having a fresh tasting mouth and good breath, may become reinforcers that help maintain the regimen. However, assistance of the patient by the clinician and others in the ways described above is generally needed to sustain long-term compliance with complex regimens (Haynes et al., 1979; Garrity, 1983).

Insofar as occasions for nonadherence can be anticipated, rehearsals or preparations can be developed for avoiding noncompliance or at least for bringing the patient promptly back into compliance. If, for example, periods of travel away from home and the ordinary routine present times of special risk of noncompliance, the problem can be identified in advance and means discussed for continued adherence. Similarly, if a period of compliance default can be anticipated to precipitate a feeling of failure and despondency that may lead to spiraling noncompliance, warning about this needless defeatism can be given and ways of coping developed (Stuart, 1980).

Three Strategies for Medical-Health Compliance

Interventions to assist compliance in the medical-health field are often categorized into organizational, educational, and behavioral strategies (Dunbar, Marshall & Hovel, 1979). These 3 strategies were defined in a general way in Chapter 1.

Organizational Strategies: Organizational strategies focus primarily upon improving the routines in the clinic. Efficient use of time and personnel, good communication between clinical personnel and patients, good organization and planning and related tactics are strategies that influence rate of patient continuation in a clinic's programs. Much of this strategy depends upon the skill and knowledge of the health practitioners in the clinic about these areas and this intervention strategy is directed mainly toward improving these skills.

Educational Strategies: Educational strategies are directed toward clients and rely most heavily on instruction and the transmission of information as a means to insure that the person follows a prescribed regimen. Pamphlets, written instructions, medication labels, verbal instructions, and formal health education classes such as are offered in "well baby" clinics, child birthing programs, or diabetes management and diet programs are examples of educational strategies. Educational strategies are the traditional and most common approach to compliance, where the client is simply told what to do and why.

Behavioral Strategies: Behavioral strategies are techniques that attempt to influence compliance with performing specific tasks that have been recommended. Techniques like self monitoring of diet, amount of medication consumed, or maintaining a log of a prescribed exercise program are coupled with praise and social reinforcement by the health provider team and family members when the records establish that the client has carried out the regimen. The techniques are typically based upon operant and cognitive learning principles. These include specificity of the recommended behavior, objective criteria for determining the presence or absence of compliance with the procedure, good record keeping of the frequency of compliant and non-compliant behavior, and the frequent provision of reinforcement and/or feedback to the client and the health practitioner about the client's progress in meeting compliance behavior goals. Formal contracting between the client, the health practitioner, and members of the patient's family are often used. The emphasis is usually upon positive reinforcement or feedback to sustain the correct behavior as opposed to punishment of incorrect behavior. There is often individual tailoring of the regimen to the specific patient's needs and preferences.

Oftentimes in behavioral strategies clients' compliant behavior is reinforced by the careful record keeping and self-monitoring of some specific performance or task. The client is frequently directly reinforced by knowledge of results that he or she is maintaining the prescribed regimen as demonstrated in the daily written record of the activity.

For example, when a person is on a diet to reduce obesity, examination of a daily log of food intake that shows the person has consumed fewer than 1200 calories per day for several days can provide feedback that reinforces the continuation of the diet. Monitoring the pounds lost over the same period provides no useful information because insufficient time has elapsed for a noticeable weight loss to occur.

Interrelationships Among and Effectiveness of the Strategies: A clear distinction among the 3 strategies is not entirely possible. The most effective interventions use all 3 . That is, behavioral strategies typically use educational antecedents to provide information, directions, and instructions to clients. The adoption of behavioral intervention strategies assumes an organizational component that encourages, allows, and assist the health profession team members and the client in developing and using the behavioral strategies.

Examination of the medical-health compliance literature reveals that the most common strategies are educational and organizational and that behavioral strategies are less frequently used. As Green (1979) notes while behavioral strategies are firmly anchored in behavioral science and learning theory principles, the application of these principles to health education approaches tends to remain casual, unsystematic, ritualistic, perfunctory, or neglected. It is clear, however, that when behavioral strategies are used in concert with educational and organizational strategies, client compliance rates are increased, often dramatically.

Studies comparing the effectiveness of large numbers of educational and behavioral strategies in achieving client compliance with medical and health regimens have been conducted by several researchers. Green (1979) provides a summary of this research.

Behavioral strategies have been found to be more effective than educational strategies in two main ways. First, compliance rate with the specified procedure (reduced caloric intake or regularly taking blood pressure medication) is increased. Second, the long term therapeutic outcomes (weight loss and lowered blood pressure) have been found to be greater. Behavioral strategies have been found to be more effective than educational or organizational strategies alone because they follow the 5 applied learning principles listed in Table 7

Another important finding concerns the types of monitoring and feedback that are effective in these behavioral strategies. In the medical-health area self monitoring by

Table 7: Learning principles underlying behavioral intervention strategies

Effective strategies should:

1. foster the informed consent and active participation of the client in targeting and setting specific goals for the regimen,

2. focus directly upon immediately achievable target behaviors or performance and not only on long term therapeutic goals,

3. incorporate attempts to reduce barriers to compliance by the client,

4. provide cues to the client to stimulate compliance,

5. provide regular feedback and knowledge of results to the client about the frequency and accuracy (quantity and quality) of his or her performance of the regimen or parts of the regimen.

the client and feedback to the client on his or her success in complying with the regimen is more effective when there is an immediately achievable, objective, and direct observable measure of compliance with the regimen. Monitoring and feedback based on the anticipated long term therapeutic outcome is less effective. For example, in a dietary regimen for an obese client, monitoring of the total food intake on a daily basis and using these data for feedback to the client and for dialogue with the health practitioner is much more effective than using pounds lost as the monitoring and feedback variable. In a medication regimen for a hypertensive client monitoring the amount of medication actually taken through a pill count or similar means and using this information for feedback is more effective than using drop in blood pressure as the monitoring and feedback variable (Green, 1979). One reason for this is found in applied learning principles. The variables used to monitor compliance need to be simple, observable, and immediately or nearly immediately accessible to the client and to persons assisting the client in complying with the regimen. Feedback and reinforcement for correct performance through knowledge of results needs to be frequent and ongoing. If a diabetic's dietary and exercise regimen is monitored only by biweekly visits to a clinic where weight and blood sugar levels are measured and reported, the client and the health provider have little specific information about details of compliance or failure to comply. If the client is instructed in how to maintain a daily dietary log, perhaps on an easy to use standard form, and to maintain an exercise log as well, both the client and the health provider are provided with ongoing and detailed information about the rate of, barriers to, and other patterns of compliance or noncompliance behavior. The information tallied daily by the client provides cues that are informative and immediately reinforcing to the person. The client is assured that she or he is doing well and that eventually the long term therapeutic outcomes will be realized. The daily record keeping and feedback also helps maintain compliant behavior once the therapeutic goal has been achieved or approximated.

Another reason that more immediate measures of compliance should be used is that the long term therapeutic goals are dependent upon compliance with the prescribed daily regimen procedures. That is, the obese client will not loose weight unless the dietary regimen is followed. The hypertensive client will not reduce blood pressure significantly unless the medication regimen is followed consistently over a period of time. The therapeutic outcome is a long term goal but it does not define the behavior by which the goal is to be achieved. The measure of compliance needs to be parallel to the prescribed regimen task to achieve the long term goal (Green, 1979.)

Chapter Summary

The literature on correlates of compliance indicates that several potentially manipulable factors have been identified as possible determinants of compliance. Several patient beliefs appear to stimulate compliance, including the patient's perception of his or her own susceptibility to the disease of interest, perception of the seriousness of this disease, perception of the benefits that flow from complying and perceptions about the difficulty involved in carrying out the regimen. Patient knowledge of the regimen and the general inclination to engage in pro-health behaviors are also associated with faithful compliance. Complexity, duration, and disruptiveness of the regimen being recommended also appear to influence level of compliance as does the level of social, material, and emotional support available to the patient for pursuing the regimen. Convenience and friendliness of clinic or office routines support good compliance; seeing the same clinician at each visit also seems to promote compliance. Finally, clinician-patient relationships enhance compliance when: (1) the clinician is an effective teacher of the regimen, (2) the patient takes an active and responsible role vis-a-vis the clinician, (3) the clinician and patient hold complementary expectations about mutual responsibilities in the relationship and (4) there is a warmth in the affective tone of the relationship.

Several of these correlates of compliance have been used in research efforts to improve patient compliance. However, in making these efforts it should be realized that adoption of a long-term health behavior occurs in stages. Stage one entails preparation of the knowledge base upon which specific regimen teaching is built. Stage two involves transformation of the patient from a state of receptive passivity to active engagement in regimen performance. Stage 3 tailors the recommendations for optimal fit between regimen and patient's life style. Stage 4, less intensive than the previous 3, sustains the already internalized and habituated regimen. The major task of each stage dictates the most appropriate compliance-promoting behaviors at each stage.

Organizational, educational, and behavioral strategies have been discussed along with a number of compliance enhancing methods. In his review of interventions for improving compliance with antihypertensive treatment, Haynes (1980) states that these strategies and methods do boost compliance, but that none of these are nearly as effective when used in isolation as when used in combination. When groups of patients are studied, one intervention is found to be effective with some patients and others methods are more beneficial with other patients. The prudent clinician would develop a package of intervention methods and strategies and

tailor their use to individual patients and their circumstances.

Finally, it should be recognized that a number of the promising interventions involve manipulations of clinician behaviors, attitudes, and knowledge as well as those of patients. This suggests that the "compliance problem" is more than a result of patient failure. Insofar as optimal compliance cannot be attained without significant adjustments in clinician behavior, the compliance problem indicates short-comings on both sides of the clinician-patient dyad.

Overview to the Next Four Chapters

The structure of this chapter outlines the structure of the next 4 chapters. What is known about boosting compliance of patients with recommended medical and health procedures is used to organize research and generate insights concerning how to promote increased compliance with safe work practices in industrial settings. Chapter 4 reviews the characteristics of companies that have safe work practices. Chapter 5 reviews phases of teaching and learning that appear to be present from the introduction through the institutionalization of safe work procedures in mines and factories. Chapter 6 describes organizational, educational, and behavioral approaches to implementing and operating industrial safety programs and examines the characteristics, effectiveness, limitations and interaction of each with the others. Chapter 7 discusses the health belief model and presents other value expectancy models that may help explain daily choices individual workers make between risky and safe work practices. In each of the 4 chapters the intention is to relate what is known from research about increasing persons' compliance with recommended medical and health regimens to increasing workers' regular compliance with safe work practices. The examples used to illustrate the research principles identified are often from underground coal mining.

The synthesis presented in the next 4 chapters is based upon a selective review of the published research in industrial and mine safety. As far as we can determine, this is the first attempt at such an integration. Many of the studies referenced are primary studies although research summaries are also cited where appropriate. Other interpretations of this literature are possible. The research literature that has been systematically located and organized for this project may be useful to other researchers independent of the inferences and generalizations presented in the remainder of this document.

CHAPTER 4: CHARACTERISTICS OF SAFE AND UNSAFE WORKPLACES

The first part of Chapter 3 summarizes concepts and research about the correlates of medical and health compliance. The purpose of this chapter is to note points of correspondence between this research and similar research in industrial health and safety. The intention is to more fully inform thinking about issues and methods for promoting safe work practices in the coal industry. However, the discussion may also be useful to persons interested in improving compliance with safe practices in other industrial settings.

Compliance With Safe Work Practices Defined

In medical and health settings compliance refers to the extent to which a person's behavior coincides with medical or health advice. The advice is usually in the form of a prescription for the regular use of a medication or a regimen for the changing of some life-style pattern, such as modification of diet, increasing exercise, flossing teeth, and similar activities designed to maintain or restore health.

In the industrial safety setting compliance may be defined as the extent to which a worker's behavior coincides with relatively specific and objective performance standards which describe proper and safe execution of a task. For example, a safe and proper procedure for changing a light bulb in a factory ceiling receptacle may involve using a sturdy step ladder of the appropriate height and construction, and in a specified manner. A worker may comply or not comply with the prescribed procedure. If a worker stands on the tines of a forklift and has another person raise him up to the receptacle to change the bulb, neither person would be complying with the prescribed safety practice for changing light bulbs.

In both the medical-health and in the industrial safety setting the degree of compliance depends not only upon the individual but upon the social and organizational context, the nature and complexity of the prescribed regimen, the level of the person's understanding of the risks involved, existing technology to reduce those risks, the presence or absence of this technology at the work site, the influence of peers and authority figures, as well as the motives and choices of the individuals involved (Leventhal & Hirschman, 1982).

Correlates of Compliance

Many studies of the correlates of good and poor compliance have been carried out in health and medical regimens. As was noted in the Chapter 3, these correlates tend to fall into 5 groups:

1. characteristics of the patient (most often demographic and personality)

2. characteristics of the patient's environment (family and social support, daily schedule, etc.)

3. characteristics of the treatment regimen (length, complexity, cost, etc.)

4. nature of the clinical routine (how long the patient has to wait to see a health practitioner, how appointments are made and scheduled, etc.)

5. the role of goal setting and information in strengthening compliance, and

6. characteristics of the clinician-patient interaction (verbal and non-verbal communication, interpersonal dynamics, etc.)

As in the area of medical-health compliance, where differences between patients who do or do not comply with recommended regimens are studied (Haynes, Taylor & Sacakett, 1979), descriptive studies that look at the correlates of safe and unsafe work environments are also the most frequent empirical studies in industrial and mine safety (Schaeffer, 1976). Intervention studies that seek to apply methods to improve compliance rates based upon these empirical findings have implications for policy in both areas.

Characteristics of the Person and "Accident Proneness"

As is pointed out in the previous chapter, patient characteristics have not been found to consistently discriminate between persons who comply or who do not comply. Sometimes lower social class, education, and occupation have been found to correlate with medical and health compliance but in many other studies they have not. Intelligence and personality factors have proven to not discriminate among good and poor compliers. There is some evidence for a "super" complier type of person, one who tends to comply fully with any health or medical regimen, who is generally alert to his or her health status, and who routinely takes preventive measures such as wearing seat belts, flossing teeth, controlling

diet and weight, and supervising healthful and preventive behavior for dependent children and family members (Haynes, Taylor & Sackett, 1979; Garrity, 1983). However, this group of individuals also appears to have no measurable personality characteristics that differentiate them from others who do not comply.

To our knowledge there have been no reported studies of "super" compliers in industrial or mine safety. Rather, the focus of many articles, usually nonempirical or poorly designed, tends to be toward the so-called accident "prone" person or the accident repeater. In these articles the underlying assumption is that there are demographic or personality characteristics of coal miners or other workers that cause persons to be accident prone.

In well designed and controlled correlational studies of safe and unsafe mines and industrial settings, relationships between worker personality characteristics and demographic characteristics have been found to be unrelated to accident and injury rates. Comprehensive reviews of the literature reveal that many theorists and researchers earlier hypothesized that such factors were likely to be predictive of accident susceptibility (Naval Ammunition Depot, Research and Development Department, 1971, Sleight & Cook, 1974, pp. G6-G12). Subsequent studies in the coal mining industry, funded in part to study these hypothesized relationships, have discredited these earlier views (Althouse & Hurrell, 1977; Pfiefer, Stefanski, & Grether, 1976.) Other studies of accident proneness, conceived as faulty personality style, have not proven to be useful constructs in planning industrial safety programs (Connally, 1981; Grimaldi & Simonds, 1975, pp. 493-495; Sass & Crook, 1981; Sleight & Cook, 1974, pp. G6-G12; Surry, 1971.) As Wigglesworth (1972) notes, a major advancement in industrial safety came with the separation of causation and culpability. Older notions of worker carelessness, proneness, and inattention are not empirically supported and are also not useful because they deal with global constructs which cannot be easily operationalized as direct causes of accidents. For example, it is not useful in an operational sense to say, "He was hurt because he was careless." The statement communicates nothing of a specific operational nature useful to correcting an error. It is far more useful to describe the error in operational terms, for example, "The operator was run over by a bulldozer and his legs crushed because he failed to lower the blade and set the brake after he stopped and the machine rolled backward as he stood on the track to dismount." In addition, personality characteristics of workers, such as degree of internal and external locus of control and intelligence, are not easily directly modified. It is much easier and far more effective to directly inter-

vene to correct a common performance error which is causing injuries (eg. decrease the frequency of mechanics using jack stands and jacks for climbing and reaching tasks and increase the frequency of using ladders for these tasks, (Komaki, Heinzman, & Lawson, 1980) than to attempt to identify accident "prone" mechanics and change their values and personality style. In addition, "proneness" and related concepts seem to be more closely related to the physical aspects of the work place and the social and organizational climate than to pervasive personality types (Bandura, 1982). The earlier concept of "proneness" as caused by self-destructive personality characteristics, fatalism, and external locus of control has been largely replaced by a concept of increased liability to accidents related to psychological and occupational stress (Althouse & Hurrell, 1977; Connally, 1981; Snow, 1982), the failure of workers to be taught and to learn to comply with the correct performance of tasks (Chiapone & Kroes, 1979; Komaki, Collins, & Penn, 1982), and the improper design of the work station (Peay, 1980).

There are a number of methodological and conceptual problems with earlier "proneness" studies. Accident proneness originated and continues to be defined primarily in terms of the distribution of accidents in the work place. Even in high injury rate occupations accidents are relatively rare events compared to the number of correct and uneventful performances of job tasks. One appropriate statistical model to use when interpreting the occurrence of accident data to determine if they happen with greater than chance frequency to individual workers is the Poisson distribution. This model predicts that by chance alone 9% of a given population of workers should have 39% of all the accidents and 39.5% of workers should have all the accidents. If accident proness is to be statistically demonstrated, significantly fewer than 9% of the workers must have 39% or more of the accidents observed, or 9% of the workers should have significantly more than 39% of the accidents observed (Korman, 1977). Many older studies (Kerr, 1957) and more recent studies cited eleswhere in this chapter have shown that accident frequencies for supposedly "prone" workers do not generally exceed the predicted chance distribution. The exception includes cases where stress affects work performance. Examples include workers stressed by chronic drug and alcohol abuse, bouts of severe personal, metal and physical health problems, and inadequate training, experience, and skill. It is obvious that such stressors increase likelyhood of poor task performance and increase risk of accidents. However, these conditions are not personality or character traits that make persons prone to accidents.

If the distribution of accidents is Poisson, then accidents are assumed to be a chance phenomenon. If, on the other hand, the occurrence of accidents can be described by a negative binomial distribution, it is assumed that individual differences among workers increase the probability that some of them initially will have an accident. One problem with this definition of accident proneness is that a negative binomial distribution of accidents can occur for reasons unrelated to the assumption of unequal proneness to accidents. McKenna (1983) summarizes these conditions that are not based upon the assumption of unequal proneness to accidents:

1. Negative binomial distribution of accidents can arise when accidents are correlated with exposure to risk and the differential exposure is not controlled for adequately. (A roof bolter working constantly at the face of a coal mine is more likely to suffer injuries from roof and rib falls than is a company safety inspector who spends little time at the face.)

2. In addition to exposure, there may be other variables which are determinants of the observed distribution. Accident proneness is only one of many possible explanatory concepts which could be invoked. (Examples mentioned earlier include substance abuse, illness, fatigue, and inexperience.)

3. Initial propensity among some workers for accidents is not the only assumption which can produce a negative binomial distribution of accidents. Assuming equal initial propensity, a negative binomial distribution of accidents can be produced if the occurrence of an accident at time t alters the probability of an accident at times t + 1, as is the case in chronic back injury. (Coal miners who have chronic back injuries are more likely to have more back injuries in the future from lifting and pulling tasks than are miners who have sound backs.)

A review of the early accident proneness studies and some of the problems inherent in trying to model actual distributions of accidents with mathematical probability distributions is cogently presented by Sass and Crook (1981). They also point out that there are problems of overly brief observational periods, biases in reporting, and confounding of accident and its outcome in the studies purporting to show the existence of accident proneness.

A second approach to define accident proneness is to examine the correlation of accidents occurring in two periods of time. A high correlation over time may mean that the

same people who did/did not have accidents during the first time period did/did not have them during the second period. There are problems with this approach also.

1. Interpreting the correlation coefficients generated from the negative binomial distribution is difficult. For example, if only a few people in both time periods had accidents, the correlation coefficient would be over-inflated.

2. High correlations could be the result of differential exposure. That is, people working in low/high risk jobs at time 1 stay in those types of jobs at time 2.

It is also worth mentioning that the often-stated aphorism "a few men cause the most accidents" is not evidence for accident proneness. In any chance distribution there will always be outliers, both those having many accidents and those having none.

There is lack of agreement on the existence of personal predispositions to accidents; within a single setting or across settings, and whether such a predisposition is mutable or not (Sass & Crook, 1981). McKenna (1983) does not entirely discard the idea that individual differences in accidents should continue to be explored (e.g., attention, perceptual styles, etc.). The extent that accident involvement is stable over time within a setting and across settings and identification of the personal and situational determinants of such behavior needs to be investigated. Sass and Crook (1981) stress the need to focus on the interaction between work place hazards and worker behavior and warn against the fallacy of blaming the victim inherent in a worker oriented approach. They call for study of accident prevention within a framework that includes individual, social, engineering, ergonomic, and organizational factors.

Patient demographic characteristics, intelligence, and personality style have not been found to be associated with compliance. Successful intervention studies in industrial safety and correlational studies in industrial and mine settings suggest a similar pattern. Miners tend to be no different from other workers in terms of the range of personality traits they display. They are no more fatalistic, no more externally controlled, and no more accident "prone" than other workers. Furthermore, miners in safe and unsafe mines also have been found to not differ on these and similar personality and demographic characteristics (Pfiefer et al. 1976).

About the only demographic characteristic that does seem to be related to injury rate is the age of the miner and

even here there are contradictory findings. In most studies of industrial safety the effects of age upon injury rates is usually confounded with experience, the attrition of severely or fatally injured young workers from the remaining worker population, and the increased capability of older, more experienced workers to pace themselves and to reject certain tasks and select others that may be less risky (Sleight & Cook, 1974, pp. B1-B71). These confounding factors make it difficult to determine the contribution of age to injury susceptibility.

In the United States younger miners in the 18-24 years category tend to have higher injury rates although this is not true in European mines where injury rates are higher in the 24-30 year age group. Entering workers in European mines are somewhat older and tend to be more carefully supervised for longer periods of time than in the United States (Duplinski, Nevrala, & Picalkova, 1982; Fried, et al. 1972; Whitfield, 1954). In the United States disabling lost time injury rates between mines at the extremes of low and high accident rates differ by a factor of nearly 5 for workers in the 18-24 year age category but by a factor of less than two for workers over 44 years of age (Committee on Underground Coal Mine Safety, 1982, p. 115.) That is, in unsafe mines nearly 5 times as many 18-24 year-old miners are injured as in safe mines. These data suggest that while the susceptibility of younger miners may be related to age norms for risk taking behavior, this tendency to be involved in accidents can be greatly modified by work environments that provide more adequate supervision, training, and peer support for safe performance. Mining environments are complex and it requires considerable skill to attend to relevant cues related to hazard detection, preventive action, and proper performance of complex tasks (Blignaut, 1979a, 1979b; Lawrence, 1974). For example, discrimination of "roof talk" by miners to determine if a fall is imminent or not likely for some time is a complex process that requires the simultaneous perception and processing of multiple auditory, visual, and other sensory and cognitive cues from the environment. Miners listen to "roof talk" and make decisions about whether to continue working or to leave the area. This complex skill is learned gradually over time (Michael, Saperstein, & Prout, 1973). It is reasonable that sustained periods of supervision and instruction of new miners may lower the frequency of accidents and injuries because the skills required for safe performance are complex. Compliance with safe practices in coal mining may in large part be based upon detailed knowledge of proper regimens for performing particular tasks. Compliance with medical and health regimens is known to be related to detailed knowledge of the regimen.

Characteristics of the Environment

In both the medical-health compliance research and in the industrial and mine safety field, correlational studies have identified characteristics of the environment that are related to compliance with a medical regimen or with low accident and injury rates in the work place. Particular environmental characteristics are found as consistent correlates of compliance. There appears to have been much research on this topic in industrial and mine safety and relatively less in the area of medical-health compliance. Perhaps this is because medical-health compliance is often seen and researched as a private matter involving a client and a health practitioner whereas compliance with safe practice in performance of work in a coal mine or other industrial setting is much more open to observation by others, of a much more social and cooperative nature, and perhaps more subject to influence by organizational policy, supervisor biases and attitudes, and group norms of co-workers.

In medical-health compliance the most important factor in the environment is the patient's family and its support or lack of support for the regimen (Green, 1979). Studies have also shown that compliance of persons with medical regimens, such as taking medication to control hypertension, is increased when supervisors or medical personnel in the work place assist by checking with the patient to see if the medication is being taken, and by expressing concern for and talking with the patient about his or her problem (Haynes et al. 1979; Garrity, 1983).

There are a number of well designed correlational studies in industrial and mine safety which examine the characteristics of safe and unsafe work places. The companies are usually selected because they are at the extremes of the distribution of injury rates for the particular industry. Eight major studies of this type have been carried out in the underground coal mining industry (Althouse & Hurrell, 1977; Committee on Underground Coal Mine Safety, 1982, 1983; Davis & Stahl, 1964; DeMichiei, Langton, Bullock, & Wiles, 1982; Naval Ammunition Depot, 1971; Pfiefer, Stefanski, & Grether, 1976; and Saunders, Patterson & Peay, 1976.) These studies were all carefully executed and most used large regional or national samples of matched pairs of safe and unsafe mines. Similar studies have been done in other industrial settings, usually in heavy industry which is similar to mining in a number of ways (Cleveland, Cohen, H., Smith, & Cohen, A., 1979; Simonds & Shafai-Sahrai, 1977; Smith, Cohen, H., Cohen, A., & Cleveland, 1978). The more recent correlational studies of safe and unsafe mines in the coal industry have incorporated the methods of earlier studies in both coal mines and factories. Methods typically

include extended interviews with management, supervisors, and workers, completion of questionnaires by these groups, and walk-through inspections by the research teams who use checklists and standardized recording procedures to note the existence of hazards, safety procedures, and other physical indicators of the work place environment. In addition, company accident records and statistics are usually examined along with other company documents such as agenda for management meetings. What emerges is a relatively small number of characteristics that discriminate consistently between safe and less safe work environments. Each of these studies presents a number of common findings as well as some findings particular to the specific study. Here we are interested in the more common findings.

Perhaps the major finding that emerges is the degree to which management practices are positive and proactive. Safer work places are characterized by a strong commitment of management to safety as well as to production. Safety matters appear regularly on management meeting agenda. Management accepts the responsibility for worker safety rather than shifting such responsibility to the individual worker. There is at once a more informal and open relationship between management and workers and at the same time more detail and specificity in statements of safety procedures and job performance practices. Communications among supervisors, workers, and management are more frequent, ongoing, informal, and open. There is less reliance upon only formal safety meetings and committees. The rules for proper performance of specific work tasks tend to be well communicated, to be clear and operational, to be consistently and fairly enforced, and to be regularly and redundantly communicated by several means including frequent informal meetings, posters, formal accident investigations and routine inclusion of safety matters on meeting agenda. More persons seem to be involved in hazard detection and accident prevention on an ongoing basis, including first line supervisors, workers, and top management.(5) Management tends to be efficient in planning and operations. The appropriate materials to do a job tend to arrive when and where they are needed by workers, and in the proper manner. Housekeeping, organization, and storage of materials tends to be much

(5) Interestingly, these findings are consistent with the research of Locke (1980) and his co-workers (Latham & Yukl, 1975; Locke, Shaw, Saari, & Latham, 1981). These researchers argue that management participation and supportiveness may have less to do with motivating workers than with providing a mechanism to develop and share ideas and strategies for successfully implementing safe work practices. More will be said about this in Chapter 6.

better planned and routinely carried out than in unsafe work places. There is better record-keeping, often both in relation to accidents and production and better use is made of accident information in ongoing safety instruction. In these safe work places there is sometimes less money formally budgeted for safety. However, a wide array of persons whose duties include safety matters are actively involved in the safety program. Frequently, first line supervisors, and workers participate in daily inspections and preventive interventions, to detect, remove, or control hazards. Top management personnel encourage this activity and are frequently involved in the process as well. (In less safe companies these tasks tend to be performed mainly by a designated safety officer or the staff of a safety department.) Worker attendance and morale tend to be consistently high. Maturity and experience of the workers often tend to be higher than in unsafe work places and the turnover rate in employment lower. These characteristics of safe mines and factories are summarized in Table 8

Although these correlational studies offer many ideas concerning how to develop safer work environments, there tend to be problems in implementing interventions based on these specific characteristics. Medical-health compliance interventions based on correlates of compliance have often been disappointing and have not resulted in improved frequency of patient compliance. In addition, some of the correlates of compliance in medical-health and industrial and mine safety may not be directly manipulable. For example, one correlate of compliance with safe practice found by Cleveland et al. (1979) in their study of safety record holding plants in the United States, was strong financial solvency of the company.(6) Another was that these plants tended to be located in small, rural communities with relatively homogeneous populations and stable work forces. Variables like these are not subject to manipulation by researchers or by the industry itself.

Some correlates of safe coal mines and work places may be more amenable to intervention tactics. Socio-technical systems organizational development approaches used in mine and industrial intervention programs attempt to promote outcomes concerned with increased communication, improved interpersonal relations, and more effective planning and management of safety and production routines. These

(6) The financial solvency variable may well be related to the higher accident rates for small underground coal mines as compared to larger mines as found by the Committee on Underground Coal Mine Safety (1982, 1983), although this variable was not examined in either study completed by the Committee.

Table 8: Characteristics of Safe Mines and Factories

Strong management commitment to safety
- -Safety matters regularly included on meeting agenda
- -Safety of workers viewed as management responsibility
- -All levels of management committed to and involved in safety

Positive and proactive organizational climate
- -Supportive and open relationship by management toward workers
- -Frequent, easy, two-way communication among workers, supervisors, and managers

Management efficiency in planning and operations
- -Good housekeeping and materials handling/storage
- -Shared knowledge and well coordinated activities among departments, workers, supervisors, and managers
- -Good record-keeping in production, job performance, safety, etc. and widespread sharing of this information
- -Frequent use of record data in planning and decision making

Decentralized wide involvement of persons in safety matters
- -First line supervisors and workers involved in daily inspections, hazard detection/corrections
- -Top managers encourage widespread preventive/corrective safety activity and are themselves frequently involved
- -Little reliance upon a central safety officer/staff to be mainly responsible for maintaining a safe work environment

Specificity in safety and job procedures
- -Rules for proper task performance are clearly and operationally specified
- -Regular and redundant communication of safety and proper job performance procedures by several means including:
  - -informal meetings/dialogue at the work section
  - -formal safety meetings
  - -posters including specific safety rules, procedures, reminders, etc.
  - -formal investigation of accidents or near accidents
- -Consistent and fair encouragement of safety procedures

Stable work force
- -Good worker morale and attendance
- -Little emplovment turnover
- -Experienced and older worker force

Strong financial solvency of the company
- -Company/division is earning profits
- -Good backlog of orders for products ensures future

approaches have had some success in improving both production and safety (Feidler, et al., 1983, 1984; Kjellen & Baneryd, 1983; Mills, 1976; Pasmore & Friedlander, 1982; Robinson, 1982; Trist, 1973, Trist et al., 1977).

Behavioral intervention tactics also appear to directly intervene on some of these correlates. Behavioral interventions identify and focus on the human actions required to safely perform given tasks. These strategies seek to increase routine compliance with safe work practices that prevent injuries. Examples include wearing hard hats, safety glasses when grinding metal, using proper lifting posture, and following a specific sequence of actions when shutting down and repairing machinery. These tactics are called "behavioral" because they identify and attempt to increase the frequency of specific worker acts for specific job tasks that are known to reduce risk of injury. The most successful behavioral interventions target specific performance tasks, specify means for improvement, use positive reinforcement rather than punishment, and clearly increase the joint participation of supervisors and workers in an ongoing monitoring of, and communication about the safe execution of these specific tasks.

Characteristics of the Regimen

In medical-health compliance, characteristics of the regimen have been found to influence compliance rates. Specifically, the longer the duration of the regimen the lower compliance becomes with the passage of time, particularly for a chronic as opposed to an acute illness. Greater complexity of the regimen also decreases rate of compliance. More intrusive regimens also lessen compliance. And, bothersome side effects also increase failure to comply.

In underground coal mining all of these factors probably work together to make consistent compliance with safety practices over long periods of time quite difficult. In coal mining the duration of compliance with practices to lessen injury and accidents must be continuous. The complexity of compliance stems from multiple tasks and situations in an ever changing environment where workers, massive equipment, complex machinery, and tremendous energy sources are in close physical proximity in restricted work spaces with poor visibility and loud background noise levels (Archibald, 1964; Gangal & Lavin, 1981; Kriebel, 1982). Intrusiveness of prescribed safety practices and procedures is frequently great, especially in low coal where movement is difficult. Compliance with safety procedures is often bothersome as in continuously wearing all the equipment that is prescribed (miner's belt, self rescuer, cap, cap lamp, and battery,

dust mask, safety glasses, and sounding tool,) or setting a temporary roof jack when leaving the protection of the roof-bolter canopy. Another example might be the need to repair a damaged electrical cable to a shuttle car, a frequent occurrence in coal mines. The electrician may choose to work on the energized cable rather than stoop walk or crawl 200 yards to the power substation and lock out the line, crawl back to the cable, make the repair, and return to the substation to unlock the line and reenergize the cable. Or the electrician may shout to another miner who happens to be near the substation and ask that he or she "lock out line 6," and then proceed to work on the cable. This is an unsafe procedure because the co-worker may not hear, may fail to lock out the line, may lock out a line other than the one to be repaired, or may energize the line before the repair is complete. The cost in terms of time and effort to the electrician is so great it is easy to make a performance error and to not follow safe procedure. It is precisely these types of contingencies that lead to a high frequency of electrocutions and other accidents in underground coal mines (Barry & Associates, 1972; Snyder, 1983).

In coal mining and other industrial settings ergonomics provides the best approach to improving characteristics of the regimen. Changing and improving the design of the work environment to lessen the probability of performance errors as in the use of dead-front panels in electrical equipment (Morley, 1983), the uses of electronic machine guarding that detects a person's presence in a dangerous area and stops a machine (Vartiala, 1982), or similar ergonomic approaches promote safety and efficient performance (Bockosh, Peay, & Wiehagen, 1982; Hakkinen, 1983; Peay, 1980; Wigglesworth, 1972).

Ergonomic approaches also have limitations. Although there is much room for improving the ergonomic design of coal mining equipment (Peay, 1980), there is evidence that a human factors engineering approach that ignores the organizational context in which the worker functions does so at its own risk (Perrow, 1983). Factors that limit the impact of ergonomic solutions include lack of incentives for top management to introduce and foster such an approach. Ergonomic changes in equipment design are often costly. Also, the human factors engineer is sometimes seen by management as a "friend" of the worker who attempts to deflect the causes of errors and accidents away from the worker and towards the equipment or system. Historically, in the coal mining industry the tendency has been to blame the worker for errors and accidents (Teleky, 1948). Implementation of ergonomic solutions to prevent or reduce injuries is sometimes seen as admission of culpability by management. Perrow (1983) is concerned with engineering solutions that have

negative consequences for the kinds of social interactions required to maintain satisfactory levels of safe performance (e.g., work stations that create barriers to communication among workers). Perrow is also concerned with the ergonomic tendency to think of the human operator as a "component" who can be assigned any one of several transfer functions while ignoring the complexity of individuals' motivations, problem solving capabilities, interests and preferences, and skills. Engineering advances that make work safer often have other unanticipated side effects. For modern coal mining equipment two of these are increased noise level that interferes with communication and increased dust. While the equipment makes coal mining much more productive and safer, these and similar side effects present new hazards.

Nature of Management Routines

In the medical compliance research, management routines concern how long persons are kept waiting in a clinic for medical or health treatment, how the appointments are scheduled and planned, and how when, and if persons are contacted if they miss appointments or if they need follow-up treatment. Pleasant, efficient management of the clinic so that patients do not have to wait for long periods, where good records are maintained, and where appointments for follow up visits are made explicitly and at the time of an earlier visit are supportive of patient compliance.

Many of the issues noted in the earlier section about characteristics of safe and unsafe work environments may be related to this area of routines. Presented earlier, they will only be summarized here. The efficiency and manner with which a company conducts and plans its daily activities reveals its management routines. Workers may be put off by inefficiency, poor planning, confusion, and poor communications. In addition the way a company presents and operates its refresher training and safety programs may be similar to the way in which medical-health clinic routines are more or less effective in achieving compliance. Safety programs undoubtedly have a greater chance to be effective to the degree that they do not demoralize or demean workers. When programs are impersonal, offered at inconvenient times, presented in uncomfortable settings, boring, and perceived by management as a "necessary evil" required by the law rather than as a major responsibility to the worker, they may tend to lower compliance with prescribed safety procedures. In these types of situations the need for individual worker compliance with safe work practices is greater than in companies with more positive management styles and safety programs. The paradox is that even though workers know how to comply, and the importance of doing so for their personal

well being, they may choose to frequently act unsafely as an expression of protest against an onerous management style or safety program. The solidarity of the work crew may develop and dictate strong group norms that actually prescribe frequent unsafe acts and prohibit routine individual adherence to "company" safety practices (Vaught & Smith, 1983). Throughout this project we heard many first hand accounts of such "protests" through unsafe acts of coal miners. Smoking in the mine, failing to take methane readings, shooting the face without stoppings, moving under unsupported roof, and even the destruction of SCSR breathing apparatus were examples cited.

The point of all this is that in the mines, as in the medical clinic, the routines of the management staff communicate strong messages to the individual. Pleasant, efficient, honest, and open routines tend to enhance individual worker compliance with safe work practices. Onerous routines tend to prevent adherence to safe work practices.

Worker-Supervisor Interactions

Four main categories have emerged from the health compliance literature concerning clinician-patient interactions. These are: the teaching style of the clinician, the match of expectations between patient and clinician, the locus of the responsibility in the clinician-patient dyad, and the affective tone of the relationship (largely dependent upon the interpersonal competence of the clinician). All are related to patient compliance (Haynes, et al., 1979; Garrity, 1983).

Generally, clinicians who are logical, well organized, and who use simple, clear, accurate, and redundant language in their verbal instructions, and who also focus on specific behaviors to be carried out, increase patient compliance. Explicitness of the clinician's instructions to the patient, use of written pamphlets, answering patient's questions, all increase compliance. If patients expect the clinician to answer questions, to provide details about medication or the illness, and if the practitioner fails to do so, patients are sometimes alienated and compliance lessens.

When patients are active collaborators and planners along with the clinician about how to carry out the regimen, compliance tends to increase. Techniques like having the patient "author" the treatment regimen with the nurse or physician, or being asked by the health provider to develop specific questions about the regimen before the next meeting have been shown to increase compliance (Garrity, 1983). These tactics achieve what is often called getting the

client to "own" his or her problem, in this case, how to stay on a difficult medical or health regimen, such as a diet or exercise program.

"Approachability" and sincerity of the health provider is also related to compliance. Signs of sincerity and "approachability" include inviting the patient to ask questions, greeting patients as they enter, bidding them farewell when the leave, being friendly toward, respectful to, and interested in the patient, and not "clock-watching," making "quick getaways," or being sarcastic (Garrity, 1983).

These types of health provider characteristics probably have relevance in the industrial work setting including coal mining as they are involved in the interaction among a supervisor and workers, especially when proper work performance and safety practices are being instructed. No specific controlled studies which attempted exclusively to manipulate these variables are known to us from our literature review of industrial and mine safety research. However, there are many anecdotal accounts of intervention experiments that succeeded or failed because of the competence or lack of competence of supervisors in these types of skills. The socio-technical systems approach to improve quality of the work environment also focuses on improving the clarity, quality, and cooperative nature of worker-management interaction. It is clear that the management training that results from these interventions is directed toward fostering interpersonal skills like those found to be present in effective clinicians. Another goal is to help workers "own" their problems and become more autonomous. And, like the case for medical compliance, these types of interventions to train management, supervisors, and workers lead to greater compliance with safe practices, decreased safety violations, and higher production (American Labor Education Center, 1980; Mills, 1976; Trist, et al. 1977). In addition, a number of other successful intervention studies have attempted to specifically teach supervisors many of these component skills, although the unique contribution of these increased supervisor competencies in interpersonal and communication skills to increased correct job performance and improved safety practices has typically not been assessed (Fiedler et al. 1983; Uslan, et al. 1978). It is also clear that many of the instructional materials that have been developed for management and supervisory training in industry and in mining promote such skills. Typically there are specific modules which deal with these types of competencies (Bureau of Mines, 1978b; Eckles; Tuttle, Wood, Grether, & Reed, 1974). The Tuttle et al. (1974) diagnostic safety form and the related instructional action modules provide specific assessment and training procedures directly related to these types of skillful interactions between supervisor and work-

ers. The procedures are based upon earlier reviews of management and organizational development strategies found to be effective in increasing compliance with safe practices and injury reduction (Tuttle, Grether, Liggett, & Killian, 1973; Tuttle, Grether, Killian, Reed, & Liggett, 1973).

It is also likely that the dramatic effectiveness of increased safe performance of tasks by workers and subsequent reductions in accident and injury rates that have resulted from well controlled behavioral interventions (Cohen & Jensen, 1984; Komaki et al. 1978, 1980, 1982, Reber & Wallin, 1984) occur in large part because of the emphasis upon clarity, specificity, and simplicity in communication between management and workers about what the correct performance regimens are. Both the clusters of behaviors selected for modification and the observational measurement procedures developed insure redundancy and clarity in communication of specific performance procedures. A main objective is to be clear so everyone involved understands precisely what the intervention is, why it is prescribed, and how it is to be accomplished. These studies typically provide 30 to 45 minute sessions with workers by section during which slides of safe and unsafe performance of specific tasks are shown and discussed, rules and procedures for safe and proper performance are made explicit, workers are asked to articulate these rules in their own words, and the procedures for observing the presence or absence of the prescribed safe performance are described. In addition, the rules are usually posted. Later in the treatment phase the frequent observations of worker performance by observers are posted publicly as graphs showing percentage of correct performance of specific tasks by workers eg. crossing conveyors correctly, stacking materials correctly, cleaning up oil spills immediately and correctly, using proper equipment for climbing and reaching, etc. The charts appear to stimulate worker and supervisor attention to and discussion of safety matters (Komaki, et al. 1980). Effective behavioral safety interventions appear to promote many of the characteristics found in effective health provider-client interactions, including large increases in the number of informal dialogues between groups of supervisors and workers about the frequency of worker correct performance of specific tasks.

Summary

Descriptive studies in both the medical field and in industrial safety settings point to some common characteristics associated with individual's high rates of compliance with recommended health and safety practices. These studies reveal that important correlates of compliance tend to be: the level of support (organizational, technical, social, and

peer) available to assist the individual in complying; the ease or difficulty in complying (cost, required effort, intrusiveness, complexity, and side effects of the procedure); the competence and interpersonal and teaching effectiveness of the health and/or safety trainer; and the opportunity and willingness of the individual trainee to be involved in setting personal goals for compliance and being frequently informed through informative feedback about his or her success in achieving these goals. In both fields compliance has not been found to be related to worker personality, character, or intelligence. Specific characteristics of safe work places are summarized from many studies and presented in Table 7.

CHAPTER 5: PHASES OF COMPLIANCE IN INDUSTRIAL SAFETY PROGRAMS

The notion of phases of compliance in industrial safety suggests that learning safety regimens, as in learning medical-health regimens, is a complex process. This learning occurs gradually over time, and requires different teaching approaches at different points.

There have been two general classes of industrial safety interventions reported in the research literature. These are the systems theory organizational development approach and the behavioral intervention approach. Parallels between phases of teaching for medical-health compliance (noted in Chapter 3), and phases of teaching for compliance with industrial safety regimens will now be examined for each of these two approaches.

Phases in Socio-technical System Interventions

The concept of phases of compliance are implicit in descriptions of industrial safety interventions, although there is little explicitly written about this topic except in the organizational development theory of Trist (1973; 1977) and by others who adopt this approach (Mills, 1976; Robinson, 1982). Generally, these researchers postulate a series of organizational development stages similar to the preparation, activation, tailoring, and sustenance phases in medical compliance. Great emphasis is placed upon the quality of the interpersonal relationships and communication among workers, supervisors, and management. The importance of workers being equal partners with management and supervisors in defining target performance areas for improvement is stressed. Collecting data on past and present performance, using feedback, tailoring procedures to meet existing worker and management needs, and providing a strong means for social reinforcement of new work regimens are all part of these approaches. Much concern is placed on the sustenance phase of the new regimens with the expectation that the task requires an ongoing, group problem solving effort that cannot occur without open communication, trust, respect, and cooperation among workers and management. Socio-technical system interventions of this type seek to implement complex work performance routines to improve safety and productivity. They have sometimes achieved dramatic results in both areas and produced added benefits of reduced stress, more enjoyment of the work place, and improved human relations among workers, supervisors, and management (Mills, 1976; Trist, 1973, 1977).

There are some major differences between these complex socio-technical systems organizational development activities and typical medical and health compliance programs. Three differences are: the number of persons involved, the nature of their relationships, and the complexity of the task. In medical-health compliance studies there is usually a single patient, his or her family, and a single or at most a few clinicians involved. The preventive or medical regimen usually consists of a single or a few related health practices such as oral hygiene, a dietary program, or exercise regimen. In the industrial organization development approach, the regimens are far less explicit, at least at first, far more complex, and they involve many more persons organized into hierarchical groups. The joint participation by persons in the industrial organizational development setting is clearly a group problem solving process and is much more complex with respect to communication, interaction of normative expectations and goals of various social groups, and the constraints of the regulatory agencies and organizations external to a particular mine, factory or plant (e.g., MSHA, OSHA, state regulations, union rules, contracts, etc.). Yet, the conceptualization of 4 phases of medical and health compliance may be useful for thinking about these and other types of industrial safety interventions.

Phases in Behavioral Safety Program Interventions

The 4 phases of compliance have their analogies in the development of effective behavioral safety programs. Table 9 provides a summary of the typical steps used by Komaki and her colleagues (1978, 1980, 1982), Reber and Wallin (1984), and Cohen and Jensen (1984) in 6 successful safety programs. The utility of thinking about compliance boosting techniques across phases of safety programs will become apparent as various studies are reviewed here and in later sections of the report.

Preparation and Activation

Industrial safety intervention studies concerned with increasing worker use of hearing protective devices illustrate some of the same stages. These studies were carried out in steel machining plants and textile mills. Decibel levels ranged from 90 to 120. Prior to the intervention programs only about 35 to 50 % of the workers regularly wore ear plugs to prevent hearing loss. In one study an effective treatment involved giving an audiogram to each worker 4 times. The first pair of audiograms were given at the beginning of the shift and again at the end of the shift on days the worker was not wearing hearing protective devices.

Table 9: Steps in Developing Effective Behavioral Safety Programs

Phase I--Preparation (antecedent activities)

Target specific tasks that are:
- -linked to past injuries,
- -behaviorally defined

Enlist assistance of workers and supervisors in each section by having them:
- -critique targeted tasks,
- -model safe and unsafe performances,
- -state the safety procedure for each task.
- -set high goals for compliance with specific safe work practices (e.g., 90% or greater).

Determine baseline level of compliance with targeted safety procedures openly, randomly, 3 or 4 times a week by:
- -observing,
- -recording,
- -graphing worker performance.

Phase II--Instruction (educational activities)

Hold a 30 to 40 minute meeting with workers and supervisors by sections where:
- -baseline data are presented,
- -advantages of working safely are discussed,
- -each specific safety procedure is demonstrated,
- -compliance with safety practices is reinforced by supervisors by verbal praise, recognition, etc.,
- -workers and supervisors are encouraged to publically affirm striving toward high rates of compliance (90% or greater),
- -procedures for the next phase are presented.

Phase III--Implementation (behavioral intervention, feedback activities, and institutionalization activities)

Continue observing, recording, and charting worker performance on targeted tasks 3 to 4 times weekly.

Display graphs of percent correct performance in the work section 3 to 4 times weekly.

Continue to have monthly or bimonthly safety meetings by sections where:

- -graphs are discussed,
- -tailoring safe work procedures and/or the work station to overcome barriers to routine compliance is planned,
- -new or potential hazards are identified.

The hearing loss was charted for the individual for that day. The daily hearing loss of workers and the cumulative hearing loss for workers with many years on the job were both posted. The information on the charts showed workers that the daily temporary hearing loss of a new worker who fails to wear protective equipment becomes a permanent loss over a period of years. Workers were encouraged to wear their earplugs prior to the second pair of beginning and end of shift audiograms. This feedback showed the worker the effectiveness of ear plugs in reducing hearing loss (Zohar, 1980a). This audiogram assessment on two different days with individual workers and, an individual session with the worker to explain the results and compare them across workers who regularly failed to use the protective devices, served as effective preparation and activation activities. Little tailoring was needed. Long term maintenance was assisted by the natural reinforcing contingency of "quietness." In addition, once the ear plugs are worn regularly, a punishing contingency develops if they are removed in the work place. The noise that has been lessened by the protectors now becomes painful. Interventions like these provide workers with needed information that may change perceptions about their susceptibility to the risk and the severity of the injury. Subsequently, goals, behavior, attitudes, habits, and social norms may change.(7)

In these and other well designed industrial safety intervention studies, the initial preparation stage tends to be relatively brief but it is critical. It is also clear in these studies that the first group to be convinced and involved must be the management. Managers often overestimate the rate of employee compliance with safety procedures, especially if the procedure is required by law or company policy (Smith, Anger, & Uslan, 1978; Zohar, 1980a, 1980b). In most cases the supervisor, or some other person appointed by the management, must assist or carry out the intervention. This involves doing the preparation required for acceptance of the safety regimen by the workers. Depending upon a single safety officer or central safety staff to carry out this role appears to be less effective than involving workers, supervisors, and managers in the cooperative identification, development, and reinforcement of specific

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(7) Interestingly, regular use of hearing protection devices also reduces accident rates in noisy environments. Noise levels are correlated positively and significantly with accident frequency but not with severity. Studies involving large numbers of workers have shown accidents to be more frequent in noisy work areas (95 dBA or greater) especially among younger and less experienced workers, and that the use of hearing protection equipment lowers accident rate (Jones, 1983).

safety regimens. In the former case there is limited value to the intervention because the company management, first line supervisors, and workers do not "own" the problem. A wide array of management and supervisory personnel are not learning a set of skills that can be used for other problems in the future. Consequently, there is little likelihood of sustaining the program. This is a feature made clear in a number of studies and guidelines (Tuttle, et al. 1974).

Companies frequently attempt to use prizes, drawings, and competitions for low accident and injury rates as "feedback" and "reinforcers" for safe work practices. However, empirical studies reveal that this approach tends to be less effective in achieving high compliance rates than regular feedback to workers, supervisors, and managers about frequency of correct performance of specific tasks. Regular feedback coupled with occasional praise and social reinforcement of correct worker performance by supervisors appears to be highly effective and to also improve the interpersonal climate of the work place. Correlational studies of safe and unsafe work places also suggest that low injury rate and safety record holding operations rely much more upon use of mutually established goals, social reinforcers, clear specification and communication of procedures, good record keeping, positive reinforcement, and social recognition for correct performance than upon competitions between crews, and extrinsic reinforcers such as prizes and drawings (Cleveland et al., 1979).

In medical compliance, having patients keep a diary of when and why they do not comply, identify the barriers to compliance, and become involved in charting their own compliance, all have been found to increase compliance because of patient knowledge-of-results and because the clinician can better tailor the regimen to the needs and circumstances of the patient. Similar techniques might be useful in industrial safety intervention studies, but to our knowledge have not been reported in the literature. Specific contracts between clinicians and patients to improve compliance rates have been effective and similar approaches have been recommended for improving compliance with industrial safety procedures (Tuttle et al. 1973a, 1973b, 1974; Fiedler et al., 1983).

Tailoring

The third phase or state of compliance in the medical area concerns tailoring the regimen to the particular patient's life style, needs,and routines. The idea is that adjustments in the regimen on an individual basis are more likely to be sustained because they help reduce the cost of

compliance for the individual. In the medical area the clinician can often intervene in specific ways to assist the patient. For example, in nutrition regimens the dietician can often suggest food or flavoring substitutions or other modifications that may reduce costs of a diet to the patient in terms of difficulty he or she may have in developing an appetite for certain foods or the ability to obtain and prepare particular foods.

In industrial safety and coal mining safety similar situations may occur. Uslan, Adelman, and Keller (1978), in their behavioral intervention study in salt mines, noted that many of the safety procedures targeted for teaching and reinforcement by supervisors were not easy to comply with. Workers, though observed and reinforced for using proper procedures, often had difficulty consistently and correctly performing some of the tasks because of individual differences in strength and stature and poor work station design. This suggests that instruction for compliance with safety procedures needs to be tailored to the individual worker, his or her height, strength, capacity for sustained physical exertion, etc. Often ergonomic interventions are needed to make it likely that the worker can comply with the prescribed practice, for example tailoring work stations to the proper height for workers of varying stature so that lifting can be done properly.

Tailoring appears to be both possible and desirable to increase compliance with industrial safety regimens much the same way tailoring serves to increase compliance with medical and health regimens. Little is said about this in most of the specific industrial safety intervention studies we have read or in the conceptual and theoretical safety literature, although much is written about tailoring machines and jobs to humans in the ergonomics literature. Generally the two--psychological/behavioral strategies and ergonomic interventions and physical design of the work station--are not conceptualized, studied or reported in conjunction with one another. It is likely that to be more effective such interventions should be planned to continue through a tailoring stage where the ergonomic aspects of the work task are modified to assist behavioral compliance with the prescribed safety regimen for the task. Otherwise, costs to workers to maintain the preventive behavior may be too high and lower compliance.

Sustenance

In medical compliance follow-up appointments in which the patient's adherence to the regimen is monitored have been shown to be important. In addition, social recognition and praise of the patient's attempts at compliance by the clinician and others, such as family members, is generally required to maintain high compliance rates. Likewise, in industrial safety, monitoring performance, providing feedback and social support of this type appears to be necessary for the maintenance of safety regimens. The exception is where the compliance procedure itself becomes reinforcing as in the hearing protection studies described earlier (Zohar, 1980). In these studies compliance with wearing hearing protective devices remains very high, often exceeding 90 to 95% even when the formal treatment is phased out and no new workers or managers are being trained in the procedures. Once the norm for wearing the ear plugs is established the natural reinforcing contingencies for continuing to do may help maintains the behavior. The norm and the contingencies are so strong that even new workers entering the plant long after the initial experiment, and when no special efforts are being made to aid compliance, begin and continue to wear their earplugs. However, compliance with most other safety routines in the work place are not as strongly naturally reinforcing and are usually quite bothersome. Typically, in behavioral safety intervention studies when the performance monitoring and feedback component of the intervention is dropped, and when social support for safe performance ceases, compliance with the prescribed safe practice drops back to its baseline levels. However, it has been demonstrated that when employees and management are mutually involved in the setting of long term goals to work safely, and when there is an attempt to model safe performance for other workers by trained workers and managers, compliance with safe work practices may be institutionalized. When this happens there is no return to baseline levels, but a continuous high level of compliance with the safe work practices (Cohen & Jensen, 1984).

In safer mines and factories, working safely remains a primary goal receiving formal attention on agenda of managers' meetings, daily attention by inspection of work places for hazards, and wide participation in these activities by workers, supervisors, and management both formally and informally. These types of activities probably help to maintain good compliance rates with safety practices. Although these generalizations are based on findings from correlational studies, there are a few intervention studies focused on trying to create such an organizational climate. These are mainly organizational development studies using the socio-technical systems approach (Mills, 1976; Trist, 1973; Trist et al. 1977; Robinson, 1982).

The well known autonomous working studies in coal mines are an attempt to create and maintain a climate that is conducive to safe and productive work practices. These studies are very complex, difficult to introduce, require the involvement of an outside "change" team, and demand great effort over extended time periods by workers, supervisors, management and union personnel to accomplish their goals. When properly implemented they achieve dramatic and lasting changes in the degree of compliance with safe and efficient production practices, and injury rates become lower and production rates increase. Yet, relatively few companies are able or willing to venture into such long-term organizational development activities. Consequently, the more specific behavioral intervention studies that focus on clusters of specific performance areas where compliance with prescribed safe work practices can reduce injury rates, may be more generally acceptable and practical for many organizations. However, one weakness of most behavioral safety programs is that they are not usually monitored for more than a year or two. Therefore, less is known in these studies about effective ways to maintain the prescribed regimens. Perhaps attention to this long term need to develop a routine monitoring process by management needs more attention in the behavioral safety intervention research. Ideas and tactics from the more complex socio-technical interventions designed to increase mine and factory safety may be useful to this end.

Summary

Learning to routinely follow safe work practices is a complex process that is acquired over a long period. Research in both medical and health compliance and industrial safety suggests it is useful to conceptualize health and safety training as occurring over 4 phases. In the first phase the individual worker must become aware of the risk and the value of the compliance procedure. In the second stage the worker must become capable and willing to routinely follow safe work practices to reduce hazards. In the third stage some aspects of the safety procedures, the job task, or the work station may have to be modified to make it easier for the worker to routinely comply with a specified safety practice. In the last stage the worker, and his or her peers and supervisors, must internalize high standards (goals) for routinely complying with safe work practices and habitually practice and monitor their daily performance of specific tasks. The 4 phases of compliance may be most useful as a global way to conceptualize what needs to be taught and what needs to be learned at each stage of a safety program from implementation through institutionalization. The next chapter provides many examples and details concerning

effective teaching and learning strategies across these phases.

CHAPTER 6: THREE STRATEGIES FOR INDUSTRIAL SAFETY PROGRAMS

Chapter 3 describes how organizational, educational, and behavioral strategies are used to boost patients' compliance with recommended medical and health regimens. This chapter calls attention to how these same 3 general strategies can be used to conceptualize and carry out programs designed to increase workers' compliance with specific health and safety practices. Explicit definitions of the 3 strategies are provided in Chapter 1 and are not repeated here.

Clarification of Terms

Before proceeding with a discussion of the 3 strategies it is important to note a difference in terminology used by behavioral scientists and by engineers and many industrial safety specialists. The term "behavioral strategy" is conceptualized and defined differently by these two groups.

Engineers and others in industrial safety research also divide interventions into 3 strategies. A typical example is Hakkinen's (1983) classification of technical, organizational, and behavioral solutions. The technical refers to ergonomic interventions where physical design of equipment leads to intrinsically safe work stations and tasks, with little or no opportunity for accidents or injury. Organizational strategies are often specified in rules, procedures, and handbooks that prescribe how management and work operations should be conducted to be safe and efficient. These usually are directed toward managers and supervisors with the intention of increasing their sophistication in the use of these procedures. For the safety engineer the term "behavioral" is broader than for the applied psychologist. For the engineer a "behavioral" intervention refers to training, instruction, the development and posting of safety rules, and the use of personal protective equipment. In Engineering literature the term "behavioral" is used to refer collectively to these types of strategies because all depend upon worker attitudes, overt behavior, choice and the like, as opposed to technical or organizational factors. Thus, in the industrial safety literature the term "behavioral" generally means some sort of educational intervention. However, here we are interested in behavioral industrial safety interventions that are consistent with the 5 learning principles outlined in Table 9 (Chapter 3). It is our intention to contrast these types of behavioral approaches with the more typical educational safety programs found in industry.

As is the case in the medical-health compliance area, true behavioral applications to industrial safety training are rarely found in the published literature. Reviews of typical safety programs reveal that most strategies are educational and organizational (Grimaldi & Simonds, 1975; Komaki, et al. 1982). Our review of the industrial safety training literature suggests that Green's (1979) observations about the usual state of medical-health training programs applies to this latter area as well. That is, here too safety intervention programs tend to be casual, perfunctory, and use of applied learning and behavioral science principles is often neglected or misinformed. In addition, most industrial safety education programs appear to be less effective than the few systematic behavioral approaches that are reported.

However, the same 3 broad strategies, organizational, educational, and behavioral, found in medical-health compliance can be found in industrial safety programs designed to prevent or lessen accident and injury rates. For example the socio-technical systems approaches of Trist and others represent effective organizational development approaches (Fiedler et al., 1983, 1984; Mills, 1976; Trist, 1973; Trist et al. 1977). Interestingly these approaches also consistently strive to foster the 5 learning principles noted in Table 7, Chapter 3. It is also clear that these major and long term studies are atypical of the usual organizational approach that consists mainly of specification of policy and promulgation of rules. Educational strategies are the most common approaches. Generally these approaches seek to inform and instruct the worker but there is little attention to behavioral methods and learning principles as Komaki et al. (1978) point out. However, it may be that in some of the safer mines and factories these learning principles and behavioral methods are routinely applied more or less informally. At least the descriptive studies of safe and unsafe work places reviewed earlier appear to indicate that the 5 applied learning principles in Table 7 are in informal operation on a regular basis for the most part in the safety programs of factories and mines with outstanding safety records (Cleveland et al. 1979; Cohen, 1977; DeMichiei et al. 1982).

As far as we know there have been no systematic studies in the industrial safety area comparing the effectiveness of typical safety education programs to behavioral safety training programs. Here we will attempt a conceptual comparison based upon examination of the safety literature and detailed study of a few well designed behavioral studies. Although there are only a few of these studies reported in a large industrial safety literature, here too behavioral strategies appear to be more effective than educational

strategies alone. They also appear easier to implement than the complex long term socio-technical systems organizational development strategies. The behavioral approaches achieve both improved compliance with immediate specific safety practices and long term goals of reduced accident and injury rates (Komaki, et al. 1978, 1980, 1982; Sulzer-Azaroff & de Santamaria, 1980; Uslan, et al. 1978).

Common Shortcomings of Safety Education Programs

In comparison to well designed behavioral intervention programs, many safety education programs are not complete. Many safety programs focus mainly on initial educational sessions for new workers where verbal and printed instructions about safe performance are presented. In behavioral approaches these activities are seen as necessary but only as antecedents to the main program. Stronger traditional safety programs provide continuing on-the-job training and supervision of new workers. Posters, signs, and periodic exhortation sessions are often used to remind workers to work safely. However, there is usually little or no feedback and positive reinforcement to workers on a regular basis for correct performance of specific tasks related to safe practice. Direct interaction of workers with supervisors and managers about safety matters may be infrequent and restricted to occasions when the worker has been involved in an accident or received an injury. The quality of the interaction is often negative and punitive with emphasis placed upon the error. The many daily correct performances of the worker that are the basis for low injury rates are often not discussed and not positively reinforced by the supervisor or other persons. Once or twice a year awards for outstanding safety performances of workers or sections are sometimes used as "reinforcers" as are drawings for large prizes for workers who qualify by virtue of low accident rates over the period since the last drawing. Neither are as effective as behavioral strategies in improving daily safe performance of specific tasks because these occasional prizes provide too little feedback on behaviors of questionable relevance and reinforcement to too few persons too infrequently to serve as effective means for improving daily compliance with safety practices. It is not that such drawings and biannual or annual awards should not be used. They do provide means for formal acknowledgement and celebration of achieving important goals. Such activity is important for maintaining social norms that ensure the goals will be cherished and striven toward. However, these celebrations are not effective means for increasing the frequency of daily safe practice of specific hazardous task by workers. These infrequent major award ceremonies lack the characteristics needed for effective behavioral strategies outlined

in Chapters 3 and 5. These characteristics include active participation by the worker in the development and achievement of a specific set of safe task performance regimens, a specific behavioral focus on proper execution of these tasks in the work place, monitoring of this performance by good record keeping, attempts by workers and management to identify and overcome barriers to compliance with the safety practice, provision of ongoing cues to the workers to stimulate compliance, the provision of frequent feedback about the worker's consistency in complying with the procedure, and relatively immediate and frequent reinforcement from this feedback as well as by occasional recognition and verbal approval by supervisors and co-workers for correct performance of the targeted tasks (see Table 9, Chapter 5).

Effectiveness of safety education programs is frequently monitored by accident and injury rate. However, as in the case of medical and health compliance, reduction of accidents and injuries are goals for and not means to compliance with specific daily safety practices. If the safe work practices are routinely complied with by workers (means), the goal of injury reduction will occur.

The accident and injury data are less effective monitoring variables for determining compliance levels with safe work practices than is direct observation of workers performing specific tasks. (Shaoul, 1976). There are two main reasons for this. First, even in factories and mines with high injury rates, the occurrence of accidents or near accidents is not frequent enough to effectively monitor the worker's daily performance. Such arrangements provide little information about the workers' safe or unsafe performance of specific tasks. Consequently, these data cannot adequately inform either the worker or the supervisor about specific changes in performance of the task needed to work safely and thus decrease accident and injury rates over a longer period of time. Second, accidents are traumatic. The typical negative and punitive nature of the interaction between the supervisor and a worker who has been involved in an accident may develop an avoidance response in both parties, so that neither are willing to seek out opportunities to talk with one another and deal with safety matters in a proactive manner. The entire context and thrust of the program may be focused on negative situations about what people are sometimes doing wrong rather than focusing upon and positively reinforcing what workers are often doing well each day in complying with safe work practices.

If the safe work regimens can be behaviorally defined and reinforced frequently the long term goal of accident reduction can be achieved. The reverse is not true because of the causal relationship between daily safe performance and

reduced injury rate. Safety programs can be effective to the degree that they target and increase the frequency of performance of specific tasks in ways designed to lessen hazard and injury. The immediate outcome desired is to increase the frequency of safe performance of these tasks, for example, increasing the frequency with which mechanics working on trucks and heavy equipment use ladders for climbing and reaching tasks and do not improvise with jacks and jack stands. Proper use of ladders for climbing and reaching decreases the long term injury rate. What can be influenced directly by a behavioral intervention program is the frequency of using ladders for climbing and reaching, not the long term goal of lowered injury rate from falls (Komaki, et al 1980). Our examination of the industrial safety literature suggests that long term safety goals are frequently confused with specific safe performance monitoring variables.

In summary, most safety programs focus on initial educational sessions for new workers. Verbal and printed instructions along with films and slides are often used to describe safe performance. Trainers often have to use very general materials and find materials specific to their situation difficult to obtain. Stronger traditional safety programs provide on-the-job training for new workers and refresher training for experienced workers. Signs, posters, bathhouse talks, and exhortations sessions are also often used. Accident investigations and reports are used for instruction as well. In safety programs that use behavioral strategies all these things are seen as essential, but mainly as antecedents to the behavioral component of the program. With respect to behavioral approaches, many safety education programs have shortcomings because they stop with organizational and educational interventions and fail to attend to the 5 learning principles required to boost compliance (see Table 7, Chapter 3). Table 10 summarizes major limitations observed in many safety programs.

Examples of Effective Behavioral Safety Strategies

Some of the well designed behavioral safety programs have been cited in Chapter 5. Here, further comments about one set of studies illustrates how behavioral industrial safety interventions parallel behavioral medical-health intervention strategies and also why they are effective. In both fields a set of common procedures appear to be effective in boosting compliance with prescribed health and safety regimens. These procedures are summarized in Table 11 These procedures have also been used in behavioral approaches to increase worker productivity, efficiency, and attendance (Prue & Bacon, 1978). However, it appears that only a few

well designed behavioral intervention studies have been devoted to increasing worker compliance with prescribed safety routines. Here we are interested in how procedures found useful for boosting compliance in medical and health settings are also appropriate in industrial safety settings.

Komaki and her colleagues have completed a series of studies of well designed industrial safety programs with large numbers of workers in 3 different types of plants or shops, a production bakery (1978), a major vehicle maintenance shop for automobiles and heavy equipment (1980), and a large poultry processing plant (1982). In the last two studies she and her colleagues used component analysis techniques to determine the unique contribution of parts of the treatment to the outcomes. Outcomes were defined in terms of the average rate of correct performance of specific tasks by section of the work place averaged across workers in that group. There were usually from 15 to 20 specific tasks for each work place that were targeted for performance improvement. The use of ladders for climbing and reaching tasks by mechanics working on heavy equipment is one task that was mentioned previously. The wearing of safety glasses while working under vehicles, or doing grinding, welding, or metal cutting tasks is another. The immediate cleaning up of any oil spills over 3 inches in diameter in any walk ways or work areas by using rice hulls or other drying material to prevent slips and falls was another targeted safety task. The wearing of protective headgear while racking birds in a poultry processing plant was another. Another was to use only the top 2/3 of the steel when sharpening a knife used in dressing the poultry. Another specified the wearing of a protective glove on the hand that holds a bird in a meat cutting operation. Still another was a specified sequence of motions and positions for pulling the gizzard from the craw to prevent the hand from slipping and the forearm from striking the waste trough over which the birds are suspended during the procedure.

In all 3 studies the specific performance tasks were selected following review of accident and injury records for a period of a few years prior to the intervention. Patterns of injury were noted and these were discussed with management, supervisors, and workers in a collaborative targeting of the specific performance regimens for each task to reduce risk of injury. It is clear that all 3 studies involved organizational interventions because supervisors and managers were involved and became supportive in implementing the program and subsequently in maintaining it. In all cases there was an educational program as an antecedent condition to the behavioral intervention. This involved 30 to 40 minute discussions with workers by sections during which the safe and unsafe performance of tasks were demonstrated by

Table 10: Common Shortcomings of Safety Education Programs in Industry

1. The program often fails to target and describe highly specific occupational tasks that warrant improvement by compliance with specific procedures.

2. Baseline data on the frequency of compliance with specific safety practices is usually unknown, and compliance rates are often over-estimated by workers, supervisors, and management.

3. The organizational policies and educational antecedents are seen as comprising the whole safety program.

4. There is failure to provide feedback to workers on a regular basis for their many correct performances of specific job tasks.

5. Long-term safety goals (reduction of accident and injury rates) tend to be confused with the means to achieve them (increased compliance with safe performance of specific targeted work tasks).

6. The attention of workers, supervisors, and management tends to be focused on accident and injury events. When these occur there are interactions about safety by these persons. The interaction focuses on what was wrong, often tends to be negative and punitive, and is generally unpleasant for all parties. Subsequently, all parties prefer to avoid safety issues and do not talk or think about them until they have to (e.g., the next accident happens).

7. Celebration of achievement of long-term safety goals (no lost time accidents for a year by a person or section) and the social recognition that goes with these events are confused with the frequent feedback and reinforcement the feedback provides. This regular feedback is required to maintain daily high levels of compliance with specific safety procedures for many occupational tasks. The social recognition and celebrations are important for maintaining organizational safety values and norms, but they are not effective in maintaining daily safety practices.

Table 11: Procedures for Boosting Compliance

These procedures have been found to be useful in medical and health compliance. They also appear to boost compliance with the safe performance of specific tasks in the work place.

1. Foster the informed consent and the active participation of the client* in targeting specific behaviors as goals for increased compliance.

2. Elicit the help of the client's social group (family, friends, and co-workers) to help achieve increased levels of compliance with the prescribed procedure (regimen).

3. Target those behaviors that are linked to illness and injury; the ones where compliance with a prescribed procedure will have the most impact on reducing risk.

4. Define each targeted behavior and procedure for compliance in specific and directly observable terms.

5. Focus the educational and training activities, and the monitoring of the client's performance, directly upon the specific targeted behaviors, not on the long-term therapeutic goals. (In a diet regimen, have patients monitor daily caloric intake or food eaten, not pounds lost. In a mine setting, monitor the number of times electrical circuits are locked out when working on electrical equipment, not the number of electrical accidents or electrocutions.)

6. Provide frequent cues to the client to help him or her remember to comply with the prescribed procedure. (Good record keeping, frequent feedback, and social support from peers and supervisors are good sources of cues.)

7. Provide frequent feedback and knowledge of results to the client concerning correct performance of a procedure. Effective means for feedback and reinforcement include:
   a) charting of percent of correct performance, and regular examination of this by the client,
   b) verbal praise and social recognition by supervisors and peers for correct performance

8. Incorporate attempts to reduce barriers to compliance by the client by tailoring the regimen or procedure to better fit the person and his or her situation.

this by the client,

b) verbal praise and social recognition by supervisors and peers for correct performance

8. Incorporate attempts to reduce barriers to compliance by the client by tailoring the regimen or procedure to better fit the person and his or her situation.

9. Include incentives for and appropriate social and community celebrations of the achievement of long-term therapeutic goals by individuals and groups, but do not confuse these with the monitoring variables.

In the medical and health area clients often do well by monitoring their own behavior on the targeted goals as in keeping dietary intake logs, exercise logs, or similar regular records. Similar procedures have been used in work settings with occupational tasks (Prue & Bacon, 1978), but mainly in the area of increasing production efficiency, not in boosting compliance with safety regimens.

*Client is here defined as the patient in a medical/ health setting or a worker or workers in an industrial setting.

color slides, discussed, and modeled by the workers. It also involved such things as posting the rules for safe performance of tasks and having weekly short meetings to discuss these safety topics and procedures. Up to this point these antecedent conditions would constitute a fairly elaborate safety education program that most companies would consider complete.

However, the main part of the behavioral intervention in these studies and in others similar to these, follows the antecedent conditions (Cohen & Jensen, 1984; Reber & Wallin, 1984; Sulzer-deSantamaria, 1980; Uslan, Adelman, & Keller, 1978). Major components were the objective charting of the percent of correct performance on each task for groups of workers by section and the frequent display of these data to the workers. These data were gathered openly by an observer who walked through each section 3 or 4 times a week at random times checking off on a simple form the frequency of correct and incorrect performance of each task. The observation typically required about 5 minutes per section. The results were plotted as graphs and also posted 3 or 4 times a week in each work section. This produced frequent and informal discussion about the results by workers and supervisors and the charts were also used in the occasional biweekly training sessions. A sample recording form and feedback graph like those used in these studies is shown in Figure 1 The text in Table 12 explains how the recording form is used. Occasional reinforcement of worker correct performance by supervisors' verbal praise was also a part of most of these studies, although this reinforcement tended to be sparse. In these and similar studies both workers and supervisors frequently report the interpersonal climate of the work place improves as the program is implemented.

It is apparent that the antecedent conditions of the Komaki et al. studies are similar to well designed factory and mine safety education programs. She and her colleagues were curious to learn what proportion of the improved compliance with safe performance of specific safety regimens could be accounted for by the antecedent educational (training) intervention and how much depended upon consequence of the feedback from the ongoing behavioral observation and public charting of the workers' correct performance rates. A base line observation of workers' correct performance rates before the antecedent educational program and the behavioral strategies were started was used as a control in a multiple baseline repeated measures design. In one study (Komaki et al. 1982), with the training or educational antecedent intervention alone, the average improvement in frequency of safe performance over the baseline value of approximately 75% increased to a value of 81%. Addition of the behavioral feedback condition (posting the graphs 3

Table 12: Explanation of Group Performance Recording Form and Graph

Forms like this one have been used in a number of studies. This sample form was adapted from procedures used in Uslan's et al. (1978) behavioral safety program in a salt mine and Komaki's et al. (1978, 1980, 1982), Cohen and Jensen (1984), and Reber and Wallin (1984) behavioral safety studies in 5 industrial settings.

The targeted behaviors are usually identified by record analysis of previous accident and injury data. All workers on a section are observed on all specified tasks. If a task is not performed during an observation it is left blank. If performed correctly, it is scored a +, if incorrectly, a -. The observer records the total observations and computes the percentage of total correct performances to total observed performances on these targeted tasks. This value is also plotted on the graph.

Observations of 5 or 10 minutes per section are scheduled on a random basis about 3 times per week. The observer functions openly within sight of workers, but comes by at random times. The observer can be a supervisor, manager, worker, or some other person and the role can rotate across these types of persons.

Over a few weeks the data can be averaged to determine a baseline level of correct performance with safety procedures on these targeted tasks.

An effective means for boosting compliance with safety procedures is the posting of the graph in the work section immediately or soon after the observation. The feedback and the social goals and cooperation this information helps generate often boost compliance rates with safety procedures by an average of 20 to 25%, resulting in an 80% reduction in lost time injuries.

The data shown here are typical of those that might be collected during a baseline period and the first week of a feedback period.

SUPERVISOR M. Smith WORK AREA Shipping OBSERVER R. Yantis

TIME OBSERVED			8:45a.m.	11:30a.m.	1:05p.m.	10:20a.m.	3:15p.m.	2:05p.m.	4:10p.m.	9:20a.m.	1:45pm	2:30pm		9:15a.m.	11:30a.m.	8:10a.m.	8:45a.m.													
DATE OBSERVED			3/18	3/20	3/13	3/27	3/29	3/25	4/3	4/16	4/8	4/10		4/2	4/3	4/6	4/7													
T A R G E T B E H A V I O R	Hard hat	1	+	−	-	+	+	−	+	+	-	+		+	+	-	+													
	Goggles	2	-	-	+	+	-	−	−	+	-	-		+	-	+	+													
	Respirator	3	−	+	+	−	−	+	-	−	+	−			+	+	-													
	Crossing Conveyor	4	+	−		+		+		+	-	+		-	+	+	-													
	Clean Oilspill	5	+	+		-	−		+	+	−	-		-	+	+	+													
	Ladder use	6	−	+			−	−	+	−	-	+		-	-	-	+													
	Clean workarea	7	+	+	-	+	+	−	−	−	+	-		+	+	+	+													
	Proper lifting	8	−	+	+	-		+	+	-	+	-		-	+	-	+													
	Look out for forklifts	9	+	+	-	+			+		-	+			+	+	-													
	Turn off machine	10	+			-	+	+	−	+	-				-	+	+													
	Proper tool storage	11	−			+	−	+	−	+		+		-	-	+	−													
	Looking in backing	12			+	-	+	+	−	+	-	-		+		+	+													
	Securing load	13		+	-	-		−	+	-		+		-	+	+														
	Pallets stacked	14	−	-	+	-	+	−		-	+				+	-	+													
		15																												
		16																												
Total Behaviors Observed			12	11	9	13	10	12	12	13	12	12		9	11	14	12													
Total Correct Behaviors			6	7	5	6	5	6	5	7	4	6		5	9	11	9													
% Correct Performance			50	64	56	46	50	50	42	54	33	50		56	88	95	75													

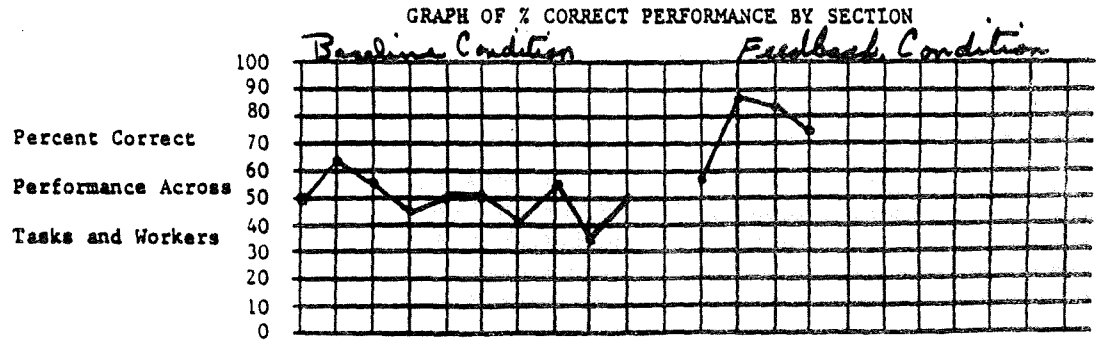

Figure 1: Sample work group performance recording form and graph

times a week) boosted compliance with safe performance of the specified tasks to a mean value of 92%. In the two earlier studies the component analysis was not carried out, but the continuation of the feedback about the rate of correct performance was shown to result in dramatic improvement of safe performance of the targeted tasks and also to subsequently lower worker injury rates. In reversal procedures, where the educational antecedents remained but no feedback to workers was presented, compliance rates with the prescribed safety practices fell to the baseline rates.

In the Komaki et al. production bakery study, within one year the plant went from the worst accident rate in the industry of 53.8 to a record winning of fewer than 10 lost time injuries per million person-hours. During this time the mean percentage of safe performance of the target tasks averaged across workers in the two departments involved in the study jumped from 70.0% to 95.8% in one department and from 77.6% to 99.3% in the other.

These generalizations, based mainly on the earlier work of Komaki and her colleagues, have recently been supported by another well designed industrial safety intervention study in a farm machinery manufacturing plant (Reber & Wallin, 1984). This study also involved a component analysis in a multiple baseline design. It compared the effects of training, goal setting, and knowledge of results of percent of worker safe performance on targeted tasks by section. For the 85 workers across the 3 sections of the plant, mean values of safe work performance were approximately 62% for the baseline, 71% for the training only, 78% for training plus goal setting, and 95% for training with goal setting and feedback to employees of knowledge of results of their safety performance. Knowledge of results was achieved by posting graphs of percent safe performance an average of 3 times a week in the work section immediately after the observer gathered the data. Goal setting simply involved getting the workers to individually and publicly agree in their group safety meetings that the goal of 90% compliance with the targeted safety procedures could be achieved, and to pledge to assist the group in reaching this overall goal of working safely at least 90% of the time.

In all of these studies regular observation of worker performance by an observer was central. The observer was either a supervisor, an outsider, or a worker. Frequent public charting of the average correct performance of workers by task in each section served as both the primary feedback and reinforcement mechanisms. The charting of performance was shown to be necessary to maintain the high level of compliance with safety practices. In one study (Komaki et al. 1980) feedback of at least 3 times a week was shown to

be necessary to maintain high levels of compliance with safety practices.

It is also interesting to note that the workers in all of these studies knew the correct procedures for safe performance of tasks, and that they routinely engaged in these safety practices from 70 to 80% of the time before the interventions. The approximately 24% increase in compliance with safety practices following the training program achieved a large reduction in lost time injury accidents. In the bakery study the subsequent injury rate dropped by a factor of more than 5. These and other behavioral safety studies cited earlier suggest that given the opportunity to set specific safety goals, the means to comply with safety practices, and regular feedback on their success in doing so, workers may reduce by dramatic amounts the rates at which they are involved in accidents.

Similar programs can undoubtedly be carried out in underground coal mines, although with greater difficulty because of the remoteness of the mine work sections from company management offices. The frequent movement of mine work sections, the poor illumination, and the changing of the mine physical layout and space as mining progresses. It is much more difficult to make frequent random observations of miners at their work sections than it is to observe factory and warehouse workers at their job in well lighted, easily accessible, and unchanging floor plan situations. However, one behavioral study designed to increase miners' compliance with safe work practices is reported in the sizable literature identified and reviewed for this project.

Rhoton (1980) used a behavioral strategy to increase underground coal miners' compliance with 5 performance variables critical to maintaining adequate ventilation to keep methane and coal dust levels low. The specific performances targeted for increased compliance by four section crews at the working face of a coal mine included: 1) taking a methane reading every 20 minutes, 2) maintaining a minimum air flow of 3,000 cubic-feet-per-minute of intake air behind the line brattice, 3) keeping methane monitoring instruments properly calibrated, 4) keeping the line brattice to within 10 feet of the working face, and 5) keeping the area behind the line brattice free of accumulated coal dust. All 5 of these performance variables are monitored by MSHA inspectors. Notices are written by inspectors when any of these performances are not being complied with. The outcome measure in the study was the number of ventilation violations recorded by MSHA inspectors per month.

The treatment in this program consisted of the experimenter (who was also a company safety officer) making a

several-hour visit to each of the 4 working sections, once a week on a random basis. During these random inspections he monitored the crew members' performance on the 5 variables. When he observed members of the crew complying with the procedures he praised them and their forman. When he observed noncompliance with one of the 5 procedures he halted production until the hazardous condition was corrected, as was required by company policy, and as was present during both the baseline and intervention phases. In addition, the experimenter prepared graphs of the MSHA ventilation violation notices each month. These were posted in the topside mine office and discussed with the section formen during regular biweekly safety meetings.

The baseline program is not explicitly described in Rhoton's (1980) article. However, it appears to have been nearly the same as the treatment intervention with a few differences. First, the company inspector appeared to be less frequently present at the working face for each crew. Second, the baseline phase apparently did not involve regular verbal praise and acknowledgement of crew members' correct performance of the 5 tasks. Third, during the treatment phase, the experimenter set and communicated to section crews a goal of zero MSHA ventilation violations per month.

The results were that the MSHA inspector ventilation violation notices dropped from an average of 2.6 per month per section during the baseline phase to 0 per month per section during the treatment phase. Interestingly, during the 14th month the experimenter was absent because of illness. During this period two MSHA notices were issued for ventilation violations. The experimenter refers to this period as "an inadvertent return to baseline." Presumably, the main treatment was the several-hour, once-a-week presence of the company safety officer closely supervising, verbally praising correct performance of the targeted tasks, and when workers failed to comply with a specific safety practice, halting production until they did so.

Although this study did use behavioral strategies, it is also quite different from the Komaki et al., Jensen and Cohen (1984) and other studies reviewed earlier. First, little is said about the antecedent educational activities that might have been used to foster the informed consent and active participation of each mine crew in the program. Second, the behaviors of the mine crews in performing these 5 tasks appear to have been closely, but relatively informally monitored. No records or graphs of the baseline rates at which mine crews correctly performed each task were produced and reported after the intervention. Rather, the records were based on the external criterion of number of MSHA inspector improper ventilation notices. Although this is a

good external criterion, it was available on only a monthly basis and it reveals less about the routine daily compliance rate of the individual miner with the safety practices, than would a formal charting of crew members' performance on each task after each observation by the company safety officer. Number of MSHA inspector ventilation violations per month is more appropriately construed as a goal than as a worker performance monitoring variable. The same 5 performances selected by the experimenter could be more formally monitored by a supervisor and workers and the data used to provide more frequent feedback to crews about percentage of daily error rates on each task. The sudden increase in ventilation violation notices in the absence of the company safety officer during the treatment stage suggests that the miners' compliance with the procedures may not have been consistently high in the absence of close supervision. Third, it appears most of formal feedback concerning rates of compliance with the targeted tasks during the intervention was directed to foremen and not to the crew members. The miners might have profited more from relatively immediate and graphic feedback, about the correctness of their performance on specific tasks on a daily or few times a week basis.

The program was effective in reducing MSHA inspection ventilation violation notices from 2.6 to 0 per month. It also targeted operational behaviors related to safe work practices. However, similar studies in the future would probably be stronger, especially in maintaining the safe behavior of miners, if more of the points in tables 8 and 11 were systematically attended to. However, the Rhoton study illustrates that behavioral safety programs can be applied in underground coal mines. It should not be faulted for its shortcomings because it occurred prior to some of the more recent industrial safety studies that have provided additional insights into how to strengthen such interventions. To our knowledge it remains the only published behavioral safety intervention study carried out in an underground coal mine.

Role of Goal Setting and Information in Sustaining Compliance

A number of the behavioral studies cited are in the tradition of operant learning theory. However, the reader may have noticed little emphasis has been placed on the term "reinforcement." Rather, the terms "knowledge-of-results" and "feedback" have predominated. Studies of the type reviewed in the previous section may also be explained in terms of goal setting and information feedback. The results of the Komaki et al. studies have been interpreted within a

cognitive information framework (Locke, 1980). It may be useful to examine some of the research in this area to better comprehend why behavioral strategies in industrial health and safety may be effective, as opposed to the lesser effectiveness of organizational and educational approaches.

The concepts of goal setting, information feedback, and modeling of coworkers and supervisors behavior, along with principles of Bandura's (1982) self-efficacy concept, have been used to design safety intervention programs that build upon the earlier work by Komaki et al. In these recent studies goal setting by workers to safely perform specific tasks 90% of the time or more, are added as explicit treatment conditions. Periodic feedback to workers by supervisors about their actual rate of compliance with targeted safe work practices are used to inform and self-reward workers toward achieving these goals. Social cooperation and modeling of appropriate safe work practices by supervisors and skilled coworkers are also included as part of the program. Two well designed behavioral safety program studies that explicitly include these types of treatment variables, along with behavioral methods, show the merit of this union (Cohen & Jensen, 1984, Reber & Wallin, 1984). The two Cohen & Jensen studies were designed to increase compliance with 14 specific safe work practices by 98 fork lift truck operators working in two warehouses. The procedures in the study were nearly identical to the Komaki et al. studies with some important distinctions. Later treatment stages were added including worker goal setting, performance feedback, and informal peer modeling. The two warehouse studies show that the addition of these treatment methods maintained the increased compliance rates. Three months after the program regular observation had stopped, truck operators continued high rates of compliance. It may be recalled that in the Komaki et al. studies, and other earlier studies as well, workers' compliance rates with specific safe work practices typically drop to pretreatment baseline levels during reversal phases when the formal observations and regular 3 times a week feedback is terminated. In the Cohen and Jensen (1984) studies, no drop was observed. Thus, goal setting, regular performance feedback, and modeling of safety practices by workers and their supervisors can be explicitly developed as program intervention methods and serve to institutionalize compliance in the absence of an experimenter and/or experimental treatment. The Reber and Wallin (1984) study of 105 workers in a farm machinery manufacturing factory did not include a delayed post-test to measure the retention of safe work practices. However, it also showed that goal setting by workers and supervisors, as well as knowledge of frequency of correct performance, both contributed to increased rates of worker compliance. As Cohen and Jensen (1984, p. 135) note, the empirical evidence from these studies suggests:

> a well designed and administered occupational safety training program, emphasizing safe work practices and derived from a true assessment of need, can be effective in improving on-the-job behavior. Even better performance can be achieved by following on goal-setting and performance feedback supplemented with informal peer group modeling. . . Further, the improved performance can endure well beyond the cessation of daily performance monitoring and feedback ...

Cohen and Jensen attribute the endurance of the safe work practices to habitual practice of the procedures, redefinition of group norms that dictate and model compliance with the practices, and continued management support.

Concepts of goal setting and information have been experimentally shown to be effective in sustaining increased compliance rates achieved by behavioral safety programs. For this reason it may be useful to examine some of the research in these areas. Although none of it has been carried out in the area of mine safety and little of it has occurred in studies of industrial safety.

Additional Theory and Research in Goal Setting

Leventhal and his associates (Leventhal & Hirschman, 1982; Leventhal, Nerenz, & Straus, 1980; Leventhal, Safer, & Panagis, 1983) have developed and explicated an approach to disease prevention and medical compliance based upon the concept of self-regulation, which in turn has its basis in control theory (Carver, 1979; Carver & Scheier, 1981; Carver & Scheier, 1982). From the perspective of Leventhal's theory of self-regulated behavior, people develop: (1) mental representations or schema of health/illness states and (2) their plans or coping strategies to deal with those states. These schema are sensitive to both the cognitive and affective/emotional perspectives of the health/illness states and the coping plans. Finally, people engage in a self-evaluative process concerning the adequacy of their mental representations. Here, we are concerned with the self-evaluation of the individual's coping plan; more specifically, with the question: "Is my criterion for success/failure appropriate?"

Perceptions of successful or unsuccessful behavior are dependent, in large part, upon the goals and the criteria used to evaluate goal achievement. We will briefly look at the following aspects of the goal setting process: (1) goal difficulty, (2) goal specificity, (3) goal timeliness, (4) goal acceptance, and (5) goal setting process. This discus-

sion relies on review articles by Carver and Scheier (1982), Leventhal and Nerenz (1982), and Locke, Shaw, Saari, and Latham (1981).

The conclusion of this research is succinctly stated by Leventhal and Nerenz (1982):

> Unreasonable goals...excessively abstract or demanding, unclear, and temporally inappropriate...doom the individual to conclude that his efforts cannot produce desired outcomes (p. 21).

The term, goal, refers to a desired level of outcome. That outcome could be defined in terms of a state of being (e.g., healthy, asymptomatic, unaffected by an exposure, not exposed to a hazard) or in terms of a level of task or behavior proficiency (e.g., proportion of times wearing a respirator, number of times washing before eating, number of times locking out a circuit before working on electrical equipment, etc.).

The evidence from many studies is unequivocal that difficult goals lead to better performance than easy, or medium goals (Austin & Bobko, 1984; Chidester & Grigsby, 1984; Locke et al. 1981), provided the individual is involved in setting the goals and has the means to achieve them. Moreover, the more specific the goals the better the performance. That is, statements of interventions to accomplish a specific measurable behavioral outcome result in better performance than intentions to simply "do one's best." The significance of goal setting for the utilization of printed communication has been discussed by Locke, et al. (1981, p. 131). People spend more time reading material relevant to their goals (compared to irrelevant material). Compared to those with no goals or nonspecific goals, people with specific goals spend more time looking at material to be learned. There would seem to be clear implications that workers who have challenging specific goals related to work practices which minimize the impact of hazardous activities should be more attentive to preventive health and safety regimens than workers without such goals. Printed and other forms of communication, such as performance graphs of percentage of workers' correct performance of specific tasks, can serve the dual purpose of helping workers define and explicate such goals and at the same time provide information that can facilitate the attainment of the goals. There is also some evidence to suggest that people who have complex, challenging specific goals become more proactive in developing strategies to accomplish those goals. Such self-motivating behavior would be especially important in relation to protecting one's self from injury in long-term hazardous work environments. From a theoretical perspective,

this "strategy development" aspect of the goal setting activity would seem to be an important component of Leventhal's self-regulation approach to prevention. This process may explain the internalization of safety procedures and regimens by individual workers who have been involved in behavioral safety programs.

Goals, by themselves, are not sufficient to improve performance to its maximum. In order for behavior to change drastically, feedback or knowledge-of-results must accompany the goal setting process (Cohen & Jensen, 1984; Komaki et al., 1980; Reber & Wallin, 1984). Moreover, feedback without the goal setting is not sufficient to change performance. In self-regulation theory, there are two types of feedback: objective and emotional. Leventhal strongly emphasizes that emotional cues are not necessarily dysfunctional or disorganizing to the individual. For example, fear engendered by physical threats is a signal to initiate appropriate behavior. The one serious problem with affective feedback is that it is relatively undifferentiated and therefore, is not maximally useful in guiding specific goal related behavior. Any number of behaviors could reduce (or enhance) affective states. Locke, et al. (1981), view feedback on goal attainment as information rather than as reinforcement, a position which is consistent with Leventhal's self-regulation theory of prevention.

There is little research on the impact on performance of temporal aspects of goals. Conventional wisdom is that it is difficult to change workers' attitudes and behaviors associated with occupational health and safety procedures because the possibility of injury, or death from the hazard seems remote in time and probability for most workers. Toxic chemicals and hazardous substances may accumulate gradually over the years in a worker's body with no apparent ill effects. There is no direct regular feedback to the worker about the hazard. Often by the time the first feedback occurs (symptoms of tissue damage) the goal of no injury is no longer possible. Consequently, there is too little information spread over too long a time period to provide feedback to the worker that might modify his or her behavior to reduce risk, or to even establish reasonable personal goals to reduce risk (e.g., wear a respirator, use protective equipment, etc.)

Industrial accidents may be thought of in a somewhat parallel way. A coal miner may go under an unsupported roof many times as a matter of convenience, each time with no ill effects. The miner may have a general goal "not to get hurt or killed." However, there is little or no feedback to the miner about this general goal from his going under an unsupported roof. The first direct feedback, a roof fall, is apt

to be fatal or near fatal. However, a goal to "not go under an unsupported roof ever!" is a difficult but more immediate and specific goal. Observations and records of the frequency of goal compliance and noncompliance based on a twice a week random observation or a self-checking procedure can provide feedback about the success of the goal achievement. Compliance with the specific goal can significantly reduce risk of injury or death from a roof fall.

On the other hand goals set at extremely short time intervals produce an over abundance of feedback and are not practical. For example, if a miner set as a goal the "sounding of the roof every thirty seconds to avoid roof falls," there would be too much information. The miner could do little else and would be ineffective. In addition, the person could not adhere to such a regimen for a variety of reasons including habituation, expectations of peers, and the need to direct attention to other tasks. Since preventive behaviors seem to entail much backsliding and variability (e.g., Marlatt & Gordon, 1980; Sjoberg, 1980), an overly fine feedback schedule may be counterproductive to stable behavior. Carver and Scheier (1982) suggest that there are optimal time frames--not too fine grained and not too widely spaced. There is little in the literature to suggest the criteria for appropriate or optimal time intervals for goals. However, in one study of an industrial safety regimen Komaki et al. found 3 times a week feedback to workers about their percentage of correct performance of specific tasks was optimum in maintaining high levels of compliance with the procedures.

Locke et al. (1981) define goal acceptance as an agreement "to commit oneself to a goal assigned or suggested by another person" where commitment refers to a determination to try to attain a goal or work toward its attainment. The empirical research in this area has methodology problems, but Locke et al. conclude that:

1. the higher the expectations of success, the higher the acceptance of the goal, and

2. the higher the perceived value of the goal the greater its acceptance.

As Carver and Scheier have noted, expectancy assessments are important in self-regulated behavior theory. Bandura (1982) notes that communication strategies that get people to believe they possess the capabilities to achieve their goals can contribute to successful performance. In addition to expectations of success and the value attached to the goal, Locke et al. report that personal goals are the best predictors of performance.

Finally, there is the important issue of the goal setting process. Conventional wisdom and a variety of empirical studies emphasize the value of participative management strategies. Locke et al. summarize the literature and conclude that participation per se does not affect performance. The possible mechanisms operating under the rubric of participation include

1. participation results in higher goals being set and it is the latter that influences behavior,

2. participation may be interpreted as reflecting greater supportiveness by management which results in enhanced goal acceptance which, in turn, leads to improved performance, and

3. participation enhances performance because it results in a broader discussion of strategies that can be used to attain the goals.

This latter mechanism is consistent with self-regulation theory in the sense that participation is a way to enhance real and perceived self-efficacy. It also is a means to share and make wider use of experience and expertise of the total group. Collective social intelligence and knowledge is generally more comprehensive than individual competence. It is also interesting to note that safety award winning mines promote these types of participating mechanisms (see Chapter 4).

Earlier studies in industrial productivity and safety have also produced similar conclusions. In an article reviewing his own earlier research and that of others, Kerr (1957) points out that the freedom of workers to set reasonably attainable goals is accomplished by high-quality work and lowered accident and injury rate. Kerr reviews a number of early studies that suggest worker opportunity to be involved in goal setting, implementing, and monitoring safe and efficient work practices tends to increase feelings of worker influence, control over the environment, competence, and self esteem. He suggests these attitudes lead to increased worker alertness to the work environment sustained over long periods of time. This results in better perfromance and reduces the number of accidents.

Summary of Goal Setting Principles

The findings from the goal setting literature may be briefly summarized. First, make goals difficult and challenging. Second make them specific. Third, try to find an optimal time interval--neither too far in the future nor too close by--with which to monitor goal achievement. Fourth, goal acceptance is facilitated if the goals are one's own. Fifth, goal acceptance is facilitated if the goals are viewed as valuable and attainable. A sense of self-efficacy is critical in the judgment of goal attainability. Sixth, it is necessary to provide regular feedback on goal attainment. Seventh, participation between workers and management in goal setting and monitoring appears to improve performance. In a meta-analysis of empirical goal setting studies concerned with increased productivity, participation of the worker in setting and accepting specific goals has been determined to account for approximately 50% of the variance in productivity (Chidester & Grigsby, 1984). Similar effects may be involved in worker compliance with specific safety performance tasks and with complying to medical regimens.

Finally, in studies of worker production setting goals that are specific and demanding typically increases quantity of correct performances by an average of approximately 17% above baseline levels (Chidester & Grigsby, 1984). Similar effects may be operating in the Komaki et al. studies which produce similar effect sizes in increased compliance with specific safety tasks, which can be construed as "goals" to work safely (Locke, 1980).

Limitations of Behavioral Strategies

It is important to qualify the success of behavioral safety programs that have been reviewed. Behavioral strategies are not substitutes for ergonomic or organizational interventions and enforcement of safety regulations. Rather, they are best used in conjunction with these more basic approaches and with antecedent and ongoing organizational and educational strategies as well. This point can be illustrated by a real life example. In a large study of Swedish woodsmen involved in tree-felling it was determined that increased training in safety would not likely lower the high injury rate for these workers. The tree-fellers already knew the safe practices for felling trees. They failed to operate safely because of problematic work production and organizational factors in the management of the industry and because of a lack of equipment such as that needed for safely dropping a felled tree that has become lodged in a second standing tree (Ostberg, 1980). In situ-

ations like this it would be foolish and irresponsible to propose a behavioral safety program as a solution to the problem. Rather, ergonomic and organizational approaches are called for. However, once the capability to safely fell trees is achieved because of improved organizational policy and because better technical procedures and equipment are available, a behavioral strategy could be useful to cue and maintain high levels of worker compliance with safety procedures.

Properly motivated and designed behavioral strategies are successful because they assist the client by calling attention to specific ways in which he or she can act to improve aspects of a situation or to achieve goals he or she desires. Setting and achievement of specific goals, assistance in overcoming barriers, and knowledge of one's progress in striving toward specific changes in life style or work patterns can be helpful in both maintaining the performance and changing the person's thinking and feeling about the situation, helping the individual and the group to seek and achieve more self direction and an increased sense of agency. This is why these types of intervention strategies have come to be called a "cognitive-behavioral" perspective (Bandura, 1982; Turk, Michenbaum, & Genest, 1983).

Conclusion

In the medical-health compliance field behavioral strategies have been determined to be more effective than educational strategies aline in achieving better compliance with regimens and better long term therapeutic outcomes. The Komaki and related studies reviewed here (see Table 6, Section 2.2, Chapter 4) suggest a similar pattern in the industrial safety field. Compliance with safety regimens and long term reduction of accident and injury rates appear to be promoted more effectively by behavioral interventions than only organizational and educational interventions. As in the area of medical compliance, optimum results require the coordination of all 3 strategies, and there are organizational and technical conditions required before behavioral strategies may be logically or ethically utilized. Furthermore, successful behavioral programs in both the medical-health and industrial safety fields are similar in their approaches. Both are consistent with applied learning principles that have been developed over the past quarter century. As noted earlier, with the exception of the Rhoton (1980) study, we are unaware of any published behavioral intervention studies in underground coal mining comparable to the many studies that have been carried out in the medical-health compliance research or the fewer studies that apply the same principles in industrial safety settings and

other mine settings. However, it seems likely that similar procedures could be applied in this area with similar results. A large empirical literature on goal setting in relation to worker participation in setting difficult and specific production goals produces findings parallel to effective behavioral medical compliance studies and effective industrial safety behavioral programs. Both schools of research call attention to effective means to boost compliance with specific goals or procedures. More recent effective industrial safety programs have profited from the theoretical examination of earlier behavioral studies from these alternative perspectives.

Two other points of potential correspondence between the research in medical-health compliance and industrial safety deserve mention. The first of these is the parallel nature of the ethical issues in research in this area in the two fields. A review of Jonsens's (1979) article "Ethical issues in compliance" reveals that most of the ethical problems (and methods for dealing with these) in the medical-health compliance research can also inform the ethics of industrial safety intervention programs. For example, to what extent is it ethical to pressure, punish, or mislead in order to improve compliance? How does one balance the values of freedom of choice and avoidance of harm, or the right to know and the obligation to try to stay well?

The second area for possible crossover of concepts is in the area of research methods. Examination of Sackett's (1979) chapter "Methods for compliance research" suggests that what has been learned in the medical-health compliance research can inform the design of industrial safety programs and evaluation studies to determine their effectiveness. The industrial safety area might profit from such a synthesis because there have been more funds available for a longer period of time for research in medical-health compliance than for studies of compliance with safety practices in the work place. Indeed, until very recently the concept of using behavioral intervention strategies in the work place to increase routine compliance with safety practices is noticeably absent from the industrial safety literature. The purpose of this chapter has been to call attention to the prospect of improving coal mine safety programs through the incorporation of these compliance boosting principles.

CHAPTER 7: VALUE EXPECTANCY MODELS OF COMPLIANCE AND SAFETY BEHAVIOR

A major approach in medical and health compliance is the health belief model (HBM) (Haynes, Taylor, & Sackett, 1979). The HBM is discussed throughout Chapter 3. There are other similar models that may be more appropriate for conceptualizing the decision behavior involved in health and safety compliance in the work place.

In this chapter, 4 value-expectancy models including the HBM are described. Each model can provide insights into some of the important variables involved in industrial health and safety compliance. These variables are of interest because they help expand our understanding (and the limits of our understanding) about why persons do or do not comply with health and safety procedures. Generally the models include variables such as the person's perceptions of the degree to which they are at risk of injury, the probable severity of the injury, the effectiveness of the preventive safety or health procedure, the cost and benefits of complying with the procedure, feelings of moral obligation to comply with social expectations and/or the safety procedures, the attitudes, values, and norms of co-workers and managers, the actual knowledge of error frequencies, and the accuracy with which actual risk can be estimated. In this chapter discussion of expectancy value models is limited to ways they may inform thinking about these key variables. Issues such as the rules for the combination and the interaction of variables within each model are beyond the scope of this paper. The 4 models summarized are: (1) the Health Belief Model (HBM), (2) the Fishbein and Ajzen Behavioral Intervention Model, (3) Triandis' choice model, and (4) Roger's Protection Motivation model.

Health Belief Model

There are two versions of the HBM, one concerned with predicting preventive health behavior (e.g., getting flu shots, brushing teeth) and one with predicting compliance to a medical regimen (e.g., taking prescribed medicine). Adherence is thought to be higher when the individual perceives himself to be vulnerable or susceptible to the illness, the disease itself is perceived to be severe, the recommended regimen is believed to be effective and the benefits to be gained by adherence are perceived to outweigh the costs. Both benefits and costs are broadly defined to include, not only financial considerations, but time, effort, life style, work, family, social interactions, etc. which could be affected. The predictions based upon the HBM have been modest (r values from approximately 0.25 to o.60,

Becker, Maiman, Kirscht, Haefner, Drachman, & Taylor, 1979) and have been exceeded by other expectancy value models such as those developed by Fishbein and Ajzen (1975), Rogers (1983), and Triandis (1982). Moreover, the HBM is not complete in that it omits several important variables from explicit consideration. It might be instructive to explore the substance of these other models as they may expand upon the HBM variables. Even more complex models developed within the context of consumer decision behavior (e.g., Howard, 1963; Howard & Sheth, 1969; Sheth, 1974) are not examined in this paper.

Behavioral Intervention Model

Fishbein and Ajzen (1975) suggest a model to predict intentions to behave which is a function of the persons attitude toward performing the behavior and his or her perception of the social norms concerning performance of the behavior. Recently some empirical research has suggested that a third component originally included in the model by Fishbein (1967), but subsequently deleted, should be considered. The third component is the individual's personal norm or sense of moral obligation associated with engaging in the behavior.

According to this model, attitudes reflect an evaluation of the consequences of engaging (or not) in the behavior and the belief that engaging in the prescribed behavior will lead to these consequences. To illustrate, the consequences of walking under an unsupported roof might include: (a) a large roof fall, (b) some flaking, (c) increased productivity, (d) less effort (e) receiving a citation, (f) demonstrating to others a lack of fear, etc. A mine foreman's attitude toward walking under an unsupported roof would be a function of his or her evaluation of each consequence (e.g., a large roof fall is very bad, increased productivity is very positive) and the beliefs that those consequences will occur (e.g., there is a very low chance of a large roof fall, there is a very high likelihood that production will be increased). Thus, this part of the formulation is similar to the HBM. The subjective norms component is defined in terms of the individual's belief that significant others (co-workers, spouse, physician, foreman, etc.) think he should engage in that behavior and the individual's motivation to comply with the wishes of those significant others. By focusing explicitly upon the social context of behavior, the Fishbein and Ajzen model seems to be appropriate to the work environment in general, and, especially, to underground mining. The importance of social norms to adherence to safety is further highlighted by Sanders' (1982) review of the lay referral networks (non-expert consultants) to health perceptions and behavior. As Sanders notes:

> The idea here is that health beliefs may predict relevant behavior, but those beliefs are likely to change as a result of nonexpert comparison information (p. 152).

The Fishbein and Ajzen model posits 3 classes of conditions which may affect the extent to which behavioral intentions are translated into action. As one reads these conditions, it is easy to understand the limitations of health beliefs as predictors of safe work place behavior. First, there is the degree to which intention and actual behavior correspond in their specificity. Thus, a general intention to "work safely" may not be related to the very specific prescribed behavior, "never walk under an unsupported roof."

Second, Fishbein and Ajzen note that intentions which are not stable may not correlate with subsequent behavior. They list several variables which could effect stability of intentions:

1. the time interval between expression of intent and the opportunity to engage in the behavior,

2. attempts to engage in the intended behavior is contingent upon successfully completing prior behaviors, (e.g., having an approved roof plan available prior to cutting from pillars or poor maintenance of mine bottom resulting in slippery spots may result in manual handling accidents even when the handler is otherwise working in an appropriate manner.) and

3. attempts to engage in the intended behavior depend upon the behavior of other people or situational events.

One of the crucial situational factors, discussed in more detail in another section of this report, is the availability of the appropriate tools, equipment, or materials. Peters (1983) and Unger and Connelly (1983) have summarized the role of materials in back injury and other accidents in underground coal mines.

The third condition which affects the likelihood that the intended behavior will be carried out (or attempted) is the degree to which engaging in the behavior is under the individual's volitional control. For example, the worker must have the knowledge and skill necessary to comply with safe work practices in order for the behavior to be considered as being volitional. Also, behavior which has become habitual or overlearned is not thought of as volitional.

The model's implications for changing work place behavior are straight forward. (Change is used here under the assumption that workers are not complying to the extent they should be and the objective is to improve the rate of safe work practices.) Fishbein and Ajzen note that one can change components of behavioral intentions or the conditions intervening between intentions and carrying out the intended behavior. To modify intention one must focus upon attitudes toward the safe Act (not toward safety in general, but toward a specific safe behavior or set of safe behaviors) and/or the subjective norms associated with performing that safe act. Problems with implementing change efforts using this model have been summarized elsewhere (Hansen, 1976; Oliver & Berger, 1979).

Triandis Choice Model

Triandis' (1980, 1982) choice model also has separate equations to predict ones' intention to behave and the probability of actually carrying that intention. According to Triandis, behavioral intentions are a function of:

1. a complex social component (described below),

2. the values attached to the consequences of engaging in the behavior,

3. the perceived probabilities that engaging in the behavior will lead to those consequences and

4. a level of arousal or affect associated with performing the behavior.

Except for the fourth component (affect/arousal) Triandis' model is similar to Fishbein and Ajzen's in terms of content. It is precisely in the affective component that the HBM has been weakest. As Leventhal, Safer, and Panagis (1983) note, the severity component of the HBM model does not generally predict behavior, and it is the severity component which is usually accompanied by fear arousal.

Triandis' social component is much broader than Fishbein and Ajzen's subjective norm. Triandis' social component includes: (a) perceptions of norms held by significant others, (e.g. co-workers, mine management), (b) whether the individual considers behavior to be relevant to the role he or she is occupying, and (c) a personal-moral obligation to perform the behavior. The social component also can include simple verbal contracts that one makes with another to perform the behavior. The introduction of role appropriateness is clearly an important attribute of behavior in the work

place. Thus, if a section foreman understands his or her role is only to maximize production, or if a miner feels that safety matters are only for the safety specialist, then it is likely that adherence to safe work practices will be inadequate.

In Triandis' choice model, the probability of actually performing the act is a function of:

1. intention to behave,

2. habit strength of the behavior, and

3. facilitating conditions or barriers to performing the behavior.

While couched in slightly different terms, Triandis' facilitating and barrier conditions are the same as those described previously under the Fishbein and Ajzen model. The implications for change are much less specific for Triandis than for Fishbein and Ajzen. The latter model calls for changing attitudes toward the act. Triandis (1982), suggests that one can address any of the components successfully; the choice being made on the basis of cost, the population, the relative impact, feasibility, etc.

Roger's Protection Motivation Model

Rogers' (1983) revised model of protection motivation contains many of the elements of the HBM, Fishbein and Ajzen, and Triandis models. Rogers attempts to incorporate fear arousal into his model thus bridging the two traditions of value expectancy and fear arousal theories. Protection motivation is a behavioral intention model and Rogers invokes Fishbein and Ajzen's 3 conditions which intervene between intention and behavior to explain that linkage. The substantive parts of Protection Motivation Theory are the predictors of intentions to engage in health protective behavior.

There are two major components of this theory which combine to produce levels of intention: (1) threat appraisal and (2) coping appraisal. One's perception of the magnitude of threat is a function of the perceived severity of the consequences and one's personal vulnerability to the cause. Severity is broadly defined to include bodily harm, threats to self-esteem, and interpersonal, work, or family problems. This conceptualization of severity is much more comprehensive then the HBM. What Rogers means by vulnerability is the degree of exposure to the hazard or the causal agents. Thus, different jobs in the mine or even spe-

cific tasks vary on the degree to which they expose workers to hazardous conditions. A recent article, Snyder (1983) points out that certain categories of mine supervisors had nonfatal accident rates which increased between 1972-1977 and 1978-1980 while there was an overall downward trend in nonfatal accidents for supervisors during that same period. Unlike HBM, where severity and susceptibility predict behavior, protection motivation theory limits the role of severity and vulnerability to determinants of threat appraisal. Fear arousal is one of the primary variables that form the perceptions of severity of consequences. Thus, arousal plays a more limited role for Rogers than for Triandis. (In the latter model, arousal was seen as a direct predictor of behavioral intention.) In addition to severity and vulnerability, threat appraisal, according to Rogers, depends upon the rewards associated with continuing (or initiating) the maladaptive or unsafe work practice (e.g., increased production, personal satisfaction, peer approval, income, etc.).

Coping appraisal refers to a self-evaluation of one's capability to engage in the remedial, preventive, or adaptive behavior. This aspect of protection motivation is clearly the major innovation of Rogers' theory. Coping appraisal is dependent upon the belief that engaging in the behavior will be effective (e.g., that correct lifting behavior will decrease lower back injuries), the belief that one has the ability to successfully perform the behavior, and the costs (broadly defined to include expense, inconvenience, effort to learn new skills, peer disapproval, etc.) of adapting the appropriate or recommended behavior.

Although Rogers is not explicit about his recommendations for change, one can assume that changes in any one of the components could potentially impact on intentions to behave. Changes in actual behavior, would, according to Rogers, follow from the Fishbein and Ajzen models recommendations.

Value Expectancy Models and Effective Safety Interventions

These value expectancy models may be useful paradigms in mine and industrial safety although they appear not to have been used in this area. Some of the research in industrial and mine safety suggests that worker involvement in safety committees, and especially in planning and implementing a safety program for one's work section, may change the worker's perception of the value of the regimen (Cohen, Smith, & Anger, 1979; Fried et. al. 1972; Komaki, Barwick, & Scott, 1978; Komaki, Heinzmann, & Lawson, 1980; Komaki, Collins, & Penn, 1982; Sulzer-Azaroff & de Santamaria, 1980; Uslan, Adelman & Keller, 1978). Effective safety interventions provide feedback on the frequency of correct and incorrect

performance to groups of workers and their supervisors on a regular basis. This aspect of a safety program may widen awareness and change behavior. The perception of management and workers about the time span over which accidents may occur, the number of workers who are susceptible to accidents, the value of routine adherence to specific safety practices, attitudes and norms that support the safety practices may change given regular information. The probability of injury to one person, from a momentary dash under unsupported roof in a coal mine is small, but the probability of injury from a roof fall to one of many persons who engage in this unsafe practice repeatedly over a long period of time is much greater. The probability of injury to an individual from a single incident of crawling under or climbing over a moving conveyor belt, rather than crossing at a safe place, is small. Yet the probability of injury to one of several workers on a section over a period of a year when they frequently engage in this behavior is much greater. Managers and workers who are involved in a safety intervention program where these types of data are routinely gathered and shared, as well as workers who become active safety committee members, safety inspectors, or safety analysts, all receive more feedback about the frequency and consequences of unsafe acts aggregated over longer periods of times and larger numbers of persons. Information like this may change perceptions of workers and managers along dimensions of value expectancy models and result in improved compliance with safety practices.

Alternatives to Value Expectancy Models

Improved industrial safety compliance that results from training programs is explained in other ways by theorists who do not necessarily adopt value expectancy models. These include:

1. increased vigilance by workers, supervisors, and management toward hazard detection (Blignaut, 1979; Edwards & Hahn 1980; Lawrence, 1974),

2. improved organizational climate resulting from selection of specific performance tasks to be performed safely and correctly, increased clarity and openness in communication among workers, supervisors and managers, about what performances are to be modified and why, and the use of positive reinforcement and the avoidance of punishment in the supervision of worker behavior, (Fiedler, Bell, Chemers, & Patrick, 1983; Komaki, et al. 1978, 1980, 1982; Sulzer-Azroff & de Santamaria, 1980; Uslan, Adelman, & Keller, 1978),

3. the changing of group norms in the work place (Blumberg, 1980; Feldman, 1984; Fiedler, et al., 1984, 1983; Kjellen & Baneryd 1983; Mills 1976; Pasmore & Friedlander, 1982; Robinson, 1982; Trist, 1973; Trist, Susman, & Brown, 1977), and

4. the improvement of individual's and groups of workers sense of control over aspects of their lives in the work place (Bandura, 1978, 1982).

These are all useful, explanatory constructs for understanding why successful safety interventions work. Earlier chapters have discussed these and other similar ideas.

Conclusion

This brief review of several of the more prominent expectancy value theories points out the lack of consensus among social scientists about the critical variables for predicting and modifying behavior. Even when there is agreement on the decision to include a particular variable (e.g., severity of outcomes,) theorists still disagree on its place in the causal linkage with subsequent behavior. Despite their differences, these 4 theories help to reinforce the importance of situational variables, social constraints, ability factors, emotions, and the degree to which the behavior is volitional as critical variables in trying to understand compliance with safe work practices. Moreover, these theories also illustrate the need to focus efforts on specific behavior and not merely on safety or safe work practices "in general".

It would be a serious mistake on our part if we were to leave the reader with the impression that safe work practices can best be understood in terms of the models of rational behavior that have been described. These theories are rational in the sense that they posit that people examine a set of alternative behaviors, estimate the likelihood of the occurrence of the alternatives, weigh these alternatives in terms of their consequences, and other constraints (e.g., social norms) perform some mental calculus and arrive at a decision to act. There is much disagreement on the extent to which rational theories capture the essence of decision behavior. This report summarizes only a very limited number of studies that describe two types of biases that impede accurate estimates of subjective probabilities of events. First, people have a tendency to drastically underestimate the probability of occurrence of negative events and second, people feel an exaggerated sense of personal invulnerability. These two tendencies may constitute part of the underlying reasons for poor adherence to self protective behavior in the work place.

Lichtenstein, Slovic, Fischoff, Layman, & Combs (1978) report that frequencies of death of most diseases are underestimated. Moreover, the lethalness of disease is underestimated relative to the lethalness of accidents; while diseases actually take approximately sixteen times more lives than do accidents. (This last finding suggests one reason why occupational health problems are even more intractable than safety problems.) The problem is exacerbated by the finding that these estimates are held with over-confidence and that such over-confidence seems relatively insensitive to attempts to change these biases (Fischoff, 1982; Lichtenstein, et al., 1977; Koriat, Lichtenstein, 1980). In a similar vein, Green (1980) notes that people underestimate the differences between the levels of safety of different activities relative to the actual differences in safety. For example, if getting killed by being crushed by equipment in a coal mine is statistically determined to be 70 times more probable than being killed by a snake bite while hiking in the mountains, persons tend to estimate the differences in probabilities as much less, perhaps as 3 to 1 rather than 70 to 1. More recent evidence from laboratory studies underscores the problems people have dealing with frequency information. In a series of studies Shaklee and Mimms (1982) report that people are extremely poor at estimating the degree of covariance between events when they must recall frequencies from memory or when they receive frequency data accompanied by distracting information. They suggest that the well known "bias" to seek confirmation of prior beliefs about event covariation and explanation rather than to make frequency based predictions may underlie attempts at understanding everyday relationships. Thus, workers' understanding of the relationship between lower back injuries and lifting behavior is probably not based upon frequency estimates of the number of times improper lifting results in injury. Rather, it is more likely to be based on filtering out and remembering those times when improper lifting had no adverse consequences. If you believe that lower back injuries are not due to improper lifting, you are likely to recall those occasions which confirm your prior belief.

Evidence for perceptions of personal immunity comes from a wide variety of research. To illustrate, people tend to overestimate their longevity (Weinstein, 1980) and their immunity to harm from the products they use (Rethans, 1979). People also think that negative events--accidents--are more likely to happen to others than to themselves. This last section on decision biases is meant to remind the reader that workers, miners, managers (and researchers) have limited and imperfect perceptual and information processing capabilities. Beyond the theoretical point of undermining models that assume rational behavior (in the sense described

above), these biases suggest other important cognitive barriers to safe work practices.

CHAPTER 8: INDUSTRY EXPERTS' REACTIONS TO PROJECT FINDINGS

An early concern expressed by the project team members was that the generalizations emerging from the literature review, whatever they might be, would be judged as irrelevant or even considered antagonistic to workers, management, and union representatives of the underground coal mining industry. Moreover, it was felt that comments from the coal mining community on the strengths and limitations of the project findings should be obtained as an integral part of the research effort and should be included as part of the final report. Consequently, early in the project plans were made to assemble 4 groups of coal industry experts to review and respond to the project findings. This chapter summarizes the reactions of a cross-section of coal miners, mine inspectors, instructors, directors of safety, union officials, state and federal governmental representatives (MSHA, USBM, KDMM, WVDM) and several other safety specialists outside of the coal mining industry. The participants at the 4 sessions come from several states including Kentucky, West Virginia, Illinois, Missouri, Ohio, Pennsylvania, and Virginia. Both large and small mining operations were represented. Lists of the participants and their affiliations are presented in Appendix C. Altogether 85 persons from the coal industry attended the 4 sessions.

The first meeting was held at the West Virginia Department of Mines' office in Charleston on May 9, 1984. Included in that meeting--a fortuitous occurrence--were members of the West Virginia Board of Coal Mine Health and Safety. The second group met at the National Mine Health and Safety Academy in Beckley, West Virginia on May 10, 1984. A third group participated at an invited presentation to the Third Annual Joint Mine Health and Safety Conference at the National Academy on May 30, 1984. The last group, consisting of inspectors, safety analysts, and instructors from the Kentucky Department of Mines and Minerals and two coal company safety directors, met at Jenny Wiley State Park on June 7, 1984.

The formats of the 4 sessions were very similar, differing only slightly in detail (the handout used at the Joint Conference and the Kentucky Department of Mines and Minerals discussions is included as Appendix D). Members of each group were informed that the session was designed to solicit their reactions to the project findings, rather than to "teach" them what had been learned. A 30 to 40 minute summary of the findings was presented using examples of effective compliance interventions with health care regimens, and with safe work practices in industry and underground salt mining. (No good case studies that illustrated the princi-

ples were available for coal mines.) The case study illustrations focused mainly on the work place because it was felt these examples were more relevant to the participants. The remainder of the two-hour sessions were devoted to questions and discussion about the merits of the ideas, their practicality, and how they might be implemented in underground mines.

The research studies used to illustrate the general principles happened to be based upon operant theory. It was not (and is not) the intention to present a review of operant theory as it applies to safety. Rather, the research illustrations presented to the groups fitted well the general principals derived from the health compliance literature (and to a lesser extent the industrial and automobile safety field). Not all safety-related research utilizing an operant approach met the general principles derived by the project team. (Absent in many studies are: (1) enlisting support of the participants, (2) preliminary group discussions and other educational activities, and (3) continuing educational activities and meetings with participants after the program is implemented).

Summary of Comments

For purposes of brevity and to maximize anonymity of the sources of the comments, individual names, organizational affiliations, and group sessions in which the comments occurred are not identified. To the extent possible, the comments follow 3 phases of intervention programs similar to those described earlier in Table 8, Chapter 4, and presented in the session handout (see Table 9, Chapter 5 and These 3 major phases include: (1) preparation/antecedent activities, (2) instruction/educational activities, and (3) implementation/behavioral intervention and feedback activities.

Preparation/Antecedent Activities

Comments on this phase of effective behavioral compliance programs primarily focused on knowledge of the problem, targeting problem tasks, miner participation, and observation.

Most, but not all, participant comments indicated that people at all levels of the organization thought they already knew the major sources of accidents in the mines. Over the 4 groups, however, there was no agreement on the sources. A strong punitive orientation to non-compliers was expressed by a few members of the groups. A few others expressed beliefs that there are accident prone miners and

malingerers. However, those expressing these views were clearly a minority of those present. Others felt that accidents occur as a result of error when workers engage in infrequently occurring activities. One safety director pointed out that records and experiences in his company showed there were "accident prone" jobs rather than persons. That is, some jobs put workers more at risk than others. In this one instance a coal company representative indicated it had conducted its own research that confirmed a conclusion of the project team (e.g., that high accident rates are strongly associated with frequent exposure to hazards in the work environment.) Others present in the meeting indicated agreement.

With some important exceptions, the notion of tailoring safety training to specific hazardous work tasks was interpreted by the participants to mean that training should be consistent with management's philosophy, the nature of the work force, local conditions, and locally used equipment. That is, selection of specific training tasks means getting away from generic safety training. In addition, identifying specific hazardous tasks and developing programs to increase safe work practices for these tasks, seemed to connote accident-type and not specific problematic work practices. Important exceptions to this interpretation come from several of the larger coal companies who attempt to diagnose problem behaviors and equipment through frequent on-the-spot observation by management audit teams and labor-management teams that identify and correct hazardous equipment and conditions.

Miner participation in the identification of problem behaviors and the development of specific safety procedures designed to enhance compliance were applauded universally by the participants.(8) It was felt if miners did not "buy into" safety as a problem to be solved, then efforts to target behaviorally specific approaches to compliance would not succeed. Miner participation in a meaningful manner was also seen as important because it signaled to miners that management was seriously concerned about safety and not merely paying lip-service to the problem.

In some published approaches to improving compliance with safety practices, baseline observations are used as a standard against which to judge subsequent interventions and as a way of documenting the extent to which appropriate and inappropriate behaviors are actually being performed. A

(8) These are two consistent contributors to increased achievement of production goals in a large number of studies. These two factors may be basic to improved compliance with specific safety procedures as well.

major purpose of this baseline data is to inform and influence worker and supervisor behavior. Both groups often do not accurately perceive how often workers place themselves at risk by not observing specific safety practices. The opinions of the participants about this matter ranged across the pessimism-optimism continuum. Virtually all of the comments made by the participants about observing behavior in underground mines are relevant both to the collection of baseline information and to the subsequent implementation phase of safety programs like those described in the case materials.

Serious concern was expressed by some participants about the ethics of observing unsafe work practices but not intervening immediately to correct the behavior. Some of this concern was eased by other participants' suggestions that only those behaviors that lead to imminent danger need to be corrected at the time of observation, while other unsafe actions can be ignored for the moment, in the interest of producing data that inform both workers and management about the normal rate of correct performance of specific targeted tasks. In one group, a member expressed the feeling that observation was only justifiable if it were coupled with immediate correction of any errors observed. In other groups persons did not express this opinion and felt that it was reasonable, and also informative and helpful, to gather baseline data. In all groups, persons felt there were some errors that were so dangerous that whenever (and by whomever) observed, immediate intervention should occur (e.g., as in seeing a miner smoking or doing something else to seriously endanger his or her and others' lives.) In all 4 groups none of the participants had knowledge of, or were aware of records of, baseline data concerning the percent of correct performance of specific tasks by workers in the mines with which they were associated.

One question discussed in each group was, "Who should do the observing?" There was agreement that it could not be done by strangers or by management. The mine face is difficult to reach from the company office. Unlike a factory floor, a casual walk through by an external observer at random times is not possible. There was no consensus on the feasibility of using as observers either foreman, miners in the section on a rotating basis, or self-monitoring by the miners (analogous to random self observation in time studies). Some persons thought the foreman was the person best suited to the role of observer because he knows best the crew members, their work assignments, and because he already observes the miners anyway as part of his normal work. Others felt the foreman could not be honest and impartial, that if his observation and charts showed that workers were correctly carrying out a procedure only 80% of the time, he and

his supervisors would be open to criticism and censure from company officials and state and federal inspectors. Most miners expressed a preference for having the observer be a member of the crew and having the position rotate.

One person expressed a concern that miners would react negatively to being observed because observation is associated with time-motion studies, and workers dislike this. Others disagreed, pointing out that observation of miners is a normal part of miner training.

Generally, the participants who were most directly involved in mining coal tended to be favorably disposed toward using observers for targeted tasks to provide feedback to improve safety. They felt such information would be useful. Persons in state and federal mine safety enforcement tended to be concerned that the observing and charting could not or would not be accurately carried out because foreman and managers would fear citations for reporting occasional failure to carry out some critical tasks like checking for methane. The purpose of the observation and performance charts as feedback mechanisms to inform and change worker behavior tended to be less well understood by participants who represented enforcement agencies. Yet, when asked if, when they were working coal miners, if such feedback on percent of correct performance would have been personally desirable and useful to them, all agreed that it would have been. Presumably, this is because they thought it would have helped to alert them to poor habits and might have improved their individual compliance rate with safety practices.

A small number of persons expressed concern about the amount of time required to carry out observations of miners on targeted tasks, because crews are typically quite far apart. Others felt this was another reason to use self-monitoring or to have the foreman or crew members serve as observers. It was also explained, that the amount of observation required was from 5 to 10 minutes, about 3 times per week. A few of the participants failed to comprehend the small amount of observation time required and suggested it would be too time consuming to make such observations. Other participants felt such observations could be readily carried out with little extra effort.

Instruction/Educational Activities

The case materials described a range of educational activities that are commonly part of effective safety programs. These activities include holding meetings with workers and supervisors by sections where several topics are discussed. The topics include sharing baseline data on the degree of correct performance of targeted tasks by workers, noting advantages of working safely, and demonstrating and modeling specific safety procedures. In addition, supervisors use praise and recognition of worker correct performance of tasks to reinforce targeted behaviors.

The participants reported that all of the activities in this second phase are already included in current mine safety training activities, with the exception of presenting base-line data. (As noted earlier, baseline data are not available.) No comments were made about this phase, except that participants were familiar with the activities and were routinely engaged in their use.

Implementation/Behavioral Intervention and Feedback

Three of the key topics that emerged from the group discussions centered on the nature of feedback, displaying feedback, and the use of continued educational sessions. It was clear that most participants did not immediately see the distinction between informational feedback and incentive/reward/interpersonal pats-on-the- back (i.e., positive reinforcement). The difference between the two concepts eventually was clarified for most of the participants by the project team members in the discussion. Nonetheless, the discussions tended to drift away from the potential utility of informational feedback for correcting work practices to the idea of positive rewards (individual and group based) for accident-free work time. Perhaps this phenomenon reflected both the participants' high value of positive rewards in shaping behavior and their tendency to view accident reduction rather than safe work practices as the important outcome of compliance programs.

Monitoring compliance with safe work practices by using objective observation of average percent of correct performance was an unusual idea for many of the participants. The discussions revealed that the majority of industry experts attending the 4 sessions tend to confuse long-term accident and injury reduction statistics (goals) with the more appropriate monitoring variables of frequency of correct performance of targeted tasks (means to the goals). The project team members present had difficulty communicating this distinction to the participants. Perhaps this difficulty

reflects a long standing emphasis upon accident and injury statistics as monitoring variables by state and federal regulatory agencies and by coal mine management and workers. If so, changing perceptions on this matter may be difficult, but may also be worthwhile.

The feasibility of posting or otherwise displaying informational feedback was also questioned by a few members in two of the groups. Appropriate locations were suggested and debated by participants. A few persons felt that miners would not attend to the feedback information. As noted earlier, the miners present tended to not feel this way. They thought the informational feedback would be useful, attended to, and could be posted on the bulletin board near each section, where calendars, production rates, pin-up pictures, and other materials are displayed. It was pointed out that miners pay close attention to posted rates in coal loading sections; suggesting that under certain circumstances information about performance would be noted. Also, as noted earlier, when inspectors and instructors in one group, all of whom were earlier working miners, were asked about the utility of informational feedback about percent of correct performance based on observing targeted performances, all agreed such information would have been useful and desirable to them personally when they were working miners.

The participants viewed very positively the aspects of the case studies where informational feedback (graphs and charts) about the percent of correct performance on targeted tasks was used for ongoing or institutionalized safety meetings by sections of workers and their supervisors. (The purpose of this activity is to maintain high rates of compliance.) In all groups the participants liked the idea that miners could talk with supervisors and among themselves about safe work practices in a positive social climate. Currently, most discussions about safety occur after a negative incident and take place in a negatively charged setting. The use of ongoing discussions about safety was also viewed positively because it would help rectify the problem of relatively new miners learning inappropriate and unsafe techniques from some of the older miners. Participants perceived these ongoing meetings as serving a socializing as well as task-learning function.

Peer Group Influence and Safety

After the workshops some participants spoke informally with the members of the project team about "problem" section crews and "problem" mines. Other miners who met with the project team on other occasions throughout the project also described these types of situations. One miner showed mem-

bers of the project team an on-the-job video tape he had filmed of a coal mine section crew he worked with. In this video tape, and in the accounts of these other individuals, it was apparent that some crews frequently engage in blatant violations of safety procedures including such things as failing to rock dust properly, smoking, failing to test for methane, shooting the face without stoppings, storing primer caps with explosives, and working under an unsupported roof.(9) It is the consensus of the experienced mine experts who spoke to us about these matters, that the peer group norms of these types of crews would contravene any of the exemplary safety programs and procedures described in the workshops.

Two important points may be made from this observation of these industry experts. The first point is that industrial and mine safety procedures like those identified in this study would likely not work with such crews until there were changes in some of the peer group norms. The procedures recommended here, even though their effectiveness is empirically supported, probably only work when miners, their supervisors and managers are cooperating to to reduce accident and injury rates. Consequently, the findings and recommendations of this report may be of value mainly to miners and mine managers who are committed to find ways to achieve increased safety. This commitment may be developed in a number of ways including:

1. rigorous enforcement of safety rules by company, union, state, and federal inspectors,

2. the reassessment of safety practices that often occurs after a mine disaster, its public condemnation, and legal action, or

3. as an organizational development activity of a company and its programs as it seeks to increase production and lower accident rates.

The second point is that no matter how specific and well designed a behavioral safety intervention is, it is likely not to be accepted, implemented, and taken seriously unless the preparation/antecedent activities are carefully carried out. Researchers in the tradition of organizational development or sociotechnical systems theory understand this feature better than most others. Perhaps mine safety programs may be better conceptualized and implemented if these

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(9) Long term on-site participant observer studies of mine crews by industrial sociologists confirm that these types of unsafe behaviors are not infrequent Fitzpatrick, 1975; Vaught & Smith, 1980).

antecedent and "process" concerns of the sociotechnical systems approach are combined with the generation and implementation of specific behavioral safety approaches with their focus on operational tasks and use of information about percent of correct performance as feedback to change perceptions and to provide information about goal achievement.

Conclusion

It appears that industry experts feel the findings have merit. In all 4 sessions participants keenly attended to the initial presentation and participated actively in the discussion. Generally, participants from all areas represented-- union, coal companies, state and federal agencies--appeared interested in and open minded about the ideas presented. The ideas most conceptually difficult for the participants were:

1. focusing on correct performance of targeted safety procedures as monitoring variables (means) as opposed to focusing on reduced accident rates (goals);

2. understanding the role of feedback on worker correct performance on targeted tasks as "feedback" for changing miner behavior to increase compliance rates, rather than viewing this information as serving regulation or "enforcement" functions.

The concepts best understood by the participants were:

1. joint miner and management participation in the identification of problem behaviors and the development and targeting of specific safety procedures;

2. the development and use of tailored instructional/educational activities.

In summary, the first two phases of safety intervention programs (preparation/antecedent and instructional/educational activities) are well understood, while the third phase (implementation/behavioral intervention and feedback activities) are least well understood. Finally, the exemplary safety program approaches outlined in the workshops, and known to be empirically effective, from studies in other industries, are likely of value to miners, supervisors, and managers who are seeking ways to boost compliance with safe work practices. For crews and supervisors like the "problem" groups described earlier, these methods probably would not be accepted or implemented, at least not until some external or internal event establishes a commitment to work safely.

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

This chapter calls attention to problems and prospects in existing practices and research in mine safety. Principles identified in Chapters 3 through 7 of this report may be applied to improve coal mine safety. Two recommendations are made. The first suggests convening a group representing behavioral researchers in health and safety and coal industry experts. This group would deal with a number of problems raised in the present study about potential behavioral science applications to mine safety. The second recommendation is to share what has been learned in this project with safety and occupational task trainers to encourage the application of specific behavioral principles outlined in this report to mine safety programs.

As noted in previous chapters, there are few well controlled safety intervention studies in underground coal mines reported in the research literature. The Rhoton (1980) study was the single example found in the large literature review undertaken for this project. Principles like those recommended in this report have been effective in significantly reducing injury rates in factories by increasing workers' routine compliance with safe work practices. It is likely that behavioral safety program principles like those reviewed in Chapter 6 can be used to strengthen coal mine safety programs.

The workshop sessions with coal industry representatives (see Chapter 8) revealed that these persons were interested in and thought it worthwhile to explore the application of these safety training principles to underground coal mines. The opportunity to become involved in adapting the techniques outlined in the workshop (and in this report) to their local mines could assist operators and miners in acquiring an additional set of skills and techniques by which to increase compliance with safe work practices. Once learned from an initial trial project, the skills and techniques could be applied by the coal company and its workers continuously to increase routine compliance with safety practices in jobs and sections other than those initially involved.

Effectiveness of Behavioral Methods

In both medical and health compliance and in industrial safety studies, behavioral approaches coupled with organizational and educational approaches have proven more effective in boosting compliance than either organizational or educational approaches alone. The addition of behavioral techniques in safety programs helps ensure that all 5 phases of

effective safety intervention programs (Table 8), all 5 learning principles (Table 9), and procedures for boosting compliance (Table 11) are systematically observed. In addition, behavioral specification of particular safe work practices, the diagnosis and monitoring of performance, the use of regular feedback, and tailoring activities, coupled with coordinated antecedent and educational activities, significantly reduce the shortcomings of most safety programs (Table 10). Evidence from other industrial and medical health research suggests that parallel application of these methods in coal mines would increase rate of worker compliance with targeted safety practices, and also would probably lower injury rate and improve organizational climate with respect to safety.

Generalizability of Behavioral Procedures

The studies reviewed for this project suggest that increasing compliance with medical and health regimens and industrial safety procedures is aided by attention to the specific procedures outlined in Tables 8, 9, and 11. In Chapter 6 Locke's (1980) elegant reinterpretation of the exceptionally well designed and effective behavioral safety programs of Komaki, et al. are described. Locke suggests that constructs of goal setting, concepts similar to Bandura's (1982) self efficacy and modeling, and information as feedback help increase our understanding of how to design behavioral safety programs that are highly successful in increasing compliance of workers with safety practices. Specifically, Locke suggests it is the setting of specific, difficult but achievable goals, and the provision of frequent feedback on the attainment of these goals that are necessary to increase compliance with increased productivity or safety practices. To be effective the safety or productivity goals must be individually accepted and internalized by workers, as well as become part of the normative standards for the group. He further suggests that behavioral safety interventions are especially effective when they promote these conditions as well as focus on operational definitions and measurement of specific desired behaviors.

A recent industrial safety study of 85 workers in 3 sections of a farm machinery manufacturing plant lends further support to Locke's hypothesis. In this study a component analysis of the relative contributions of safety training, goal setting, and knowledge of worker rate of compliance with targeted safety practices was compared to baseline safe work performance. The results show that routine worker compliance with safety practices at levels above 90 to 95% require all 3 components, that is, being trained in the safety procedures, accepting the specific difficult goals,

and receiving frequent feedback about the percent of correct performance (Reber & Wallin, 1984).

Another recent component analysis behavioral safety intervention study by Cohen and Jensen (1984) carried out with fork lift truck operators in two warehouses supports the Reber and Wallin findings. In addition, the Cohen and Jensen study demonstrated that when Locke's concepts of goal setting, and other concepts of peer and supervisor modeling of the safety behaviors, were explicitly included as treatment variables in the program, there was no return to baseline rates on the targeted safety behaviors 3 months after the experimental treatment was terminated. Both of these studies were directly based on the behavioral methods and procedures used by Komaki, et al. Both also sought to include Locke's cognitive constructs in their treatment conditions. The strong positive results illustrate the utility of safety programs that combine constructs of goal setting, modeling, and information feedback with well established behavioral specification, observation, and measurement procedures.

To the extent that these principles or components can be incorporated in any industrial safety or medical-health program, the program is more likely to be effective regardless of the underlying theoretical approach used by the researcher to conceptualize why the activity works. Recent large scale meta-analysis of the empirical research literature on goal setting in improved worker productivity tends to support this claim and Locke's hypothesis (Chidester & Grigsby, 1984).

Strict operant learning theoretical frameworks are not necessary to the effective use of these methods. In addition to the cognitive and information processing theories of Locke and his colleagues, there are many other theoretical approaches that can effectively use behavioral methods. For example, the Fiedler et al. (1983, 1984) studies on management leadership training and safety in mining, reviewed in Chapter 6, could be more explicitly attentive to the specific steps and procedures outlined in Tables 8, 9, and 11. If so, these safety programs would better meet the conditions identified by Komaki and Locke. Such an approach would be appropriate if a goal of the management training was to boost compliance of workers with specific safety practices to prevent accidents, and not only to promote more general effective leadership, diagnostic, and communication skills. Supervisors and worker-leaders in Fiedler, or other types of supervisory training programs, could be taught to use work performance recording forms and graphs like those described in Figure 1 and Table 12. As the reader may recall, the form shown in Figure 1 is adapted in part from the Uslan et

al. (1978) behavioral safety program study in a salt mine where supervisors learned to target, observe, record, and reinforce worker performance of specific safety procedures. Yet the program did not fully implement the principles outlined in Chapter 6, perhaps because it failed to include workers in goal setting and to provide them with frequent feedback about their rate of compliance with the targeted safety procedures. Had it done so, and had it worked with smaller groups of workers and supervisors by sections, the program might have been more effective.

The Tuttle et al. (1973, 1973) behavioral safety guidelines for industrial and mine safety also advocate the use of procedures like those abstracted in Tables 8, 9, and 11. It is conceivable that these procedures could also be used in interventions where opinion leaders and "key workers," managers, the members of the work group themselves, or outside consultants were the persons systematically applying the techniques. Researchers and safety officers should be encouraged to incorporate these empirically tested procedures in their safety training programs no matter what theoretical framework they adopt.

Behavioral Strategies Augment Traditional Task Training

The behavioral safety intervention strategies described in this report are similar to other approaches including job instruction training (JIT) developed in World War II (War Manpower Commission, 1945); behavior modeling for managers (Moses, 1978), on-the-job-training (OJT) (Bass & Vaughan, 1966; Wilson, Olmstead, & Trexler, 1980), the Tuttle et al. (1973, 1974) behavioral safety guidelines and safety problem diagnostic and intervention system, and the strategies described by Krupp and Dahle (1984) used in 9 modules for occupational task and safety training of operators of surface mine equipment (dozers, scrapers, utility trucks, cranes, etc.) These approaches most often focus on improving job skills and proficiency or upgrading interpersonal and communication skills toward increased productivity. The Tuttle et al. guidelines include many of these other approaches as well but focus explicitly on the training of safe work practices. The materials described by Krupp and Dahle (1984) focus on training the efficient and safe operation of specific equipment.

The steps involved in these and other occupational task training approaches are similar to the steps in developing effective behavioral safety programs (see Table 8, Chapter 4). They are also similar to the 4 phases of compliance behavior induction described in chapters 3 and 5. Table 13 is from the War Manpower Commission (1945) report on train-

ing in industry. The task training procedure developed by the Commission is essentially the same as the "four step method" for industrial training outlined in Wilson, Olmstead, & Trexler (1980) 35 years later. Other approaches like the error-cause removal program (ECR) also use some of these same techniques and specifically involve teams of production workers and supervisors in goal setting, problem solving, self monitoring of error rates, and modification of both production methods and work procedures to eliminate error (Swain, 1973). In addition, as is pointed out in Chapter 4, many of these procedures are formally and informally in operation in mines and factories with outstanding safety records (see Table 7).

The behavioral safety strategies reviewed in this report do not replace or negate the advice given in these other approaches. In fact, when safety programs adopt the methods of these other approaches they tend to be effective. However, behavioral safety interventions can augment and improve the effectiveness of these longstanding safety education and training approaches. There is direct empirical evidence for this assertion in treatment component analysis studies of safety programs.

As described earlier in Chapter 6, Komaki, Heinzman, and Lawson (1980) empirically demonstrated that graphic feedback presented to workers 3 times a week based on observation of specific safe work practices significantly boosted the rate of worker compliance compared to an otherwise fairly complete safety program that would meet well the principles of JIT and similar occupational task training methods. In another experimental component analysis study, Reber and Wallin (1984) measured the contribution of formal safety rule training, goal setting, and knowledge of results (or feedback) to improved worker adherence to specific safe work practices. The safety training treatment was thorough and clearly met JIT and similar longstanding training procedures such as the "four step method." However, when incremental treatment conditions of goal setting by workers, and frequent direct knowledge of results of accuracy of worker performance were added, routine compliance with safety procedures increased each time. During the baseline, (no treatment phase) worker compliance with the specified safe work practices occurred an average of 62.20% of the time when pooled across workers and tasks. When a strong traditional safety training program was implemented, compliance with safe work practices rose to a mean rate of 70.85%. When a treatment involving employee and supervisor goal setting to work safely 90% of the time was added, compliance rose to 77.54%. When graphic feedback, based on randomly spaced observations of actual percent of correct work practices by workers in each section, was provided 2 to 4 times

Table 13: Job instruction training (JIR) strategy

Practical methods to guide you in instructing a new man on a job, or a present worker on a new job or a new skill

FIRST, here's what you must do to get ready to teach a job:

1. Decide what the learner must be taught in order to do the job efficiently, safely, economically and intelligently.
2. Have the right tools, equipment, supplies and material ready.
3. Have the work place properly arranged, just as the worker will be expected to keep it.

THEN, you should instruct the learner by the following four basic steps:

STEP I--PREPARATION (of the learner)

1. Put the learner at ease.
2. Find out what he already knows about the job.
3. Get him interested and desirous of learning the job.

STEP II--PRESENTATION (of the operations and knowledge)

1. Tell, Show, Illustrate, and Question in order to put over the new knowledge and operations.
2. Instruct slowly, clearly, completely and patiently, one point at a time.
3. Check, question and repeat.
4. Make sure the learner really knows.

STEP III--PERFORMANCE TRY-OUT

1. Test learner by having him perform the job.
2. Ask questions beginning with why, how, when or where.
3. Observe performance, correct errors, and repeat instructions if necessary.
4. Continue until you know he knows.

STEP IV--FOLLOW UP

1. Put him "on his own."
2. Check frequently to be sure he follows instructions.
3. Taper off extra supervision and close follow-up until he is qualified to work with normal supervision.

REMEMBER--If the learner hasn't learned, the teacher hasn't taught.

SOURCE: War Manpower Commission (1945).

per week, the average compliance rate increased to 95.39%. In still another recent component analysis study by Cohen & Jensen (1984) similar findings occurred. Furthermore, when goal setting and modeling of specific safe behaviors were added as treatment conditions, very high rates of routine worker compliance were maintained 3 months beyond the termination of the formal safety intervention treatment program.

All of these studies have been reviewed earlier in this report. The reason for calling attention to them again is simply to point out that behavioral safety strategies coupled with existing occupational and task training approaches increase worker compliance rates with safe work practices beyond that which is achieved only by attending to the more traditional occupational or job task training guidelines.

Behavioral safety techniques appear to make 3 additional contributions beyond those of structured OJT, JIT, ECR, and similar task training approaches that include many of the principles outlined in this report. The behavioral interventions probably achieve higher levels of routine compliance with safe work practices because they (1) empirically establish baseline data concerning the frequency of workers' correct performance of specific tasks, (2) involve workers and their supervisors in setting high goals for routine compliance with these safe work practices, and (3) provide frequent, precise visaual (usually graphic) feedback to workers in small work sections about their actual compliance rates, based on frequent random observation (measurement) of actual task performance. These specific techniques are not made explicit in earlier job training guidelines. More recently their worth has been empirically demonstrated. If safety programs combine these newer strategies with existing and long established guidelines for occupational task training, it is likely that accident and injury rates will drop.

Limitations of Behavioral Procedures

An experienced engineer and safety officer who talked with the project team called attention to a limitation of the behavioral procedures summarized and recommended in the project workshops and in this report. This engineer strongly approves of the behavioral procedures and was convinced by the empirical research reviewed in this project, and by his practical past experience, that application of the methods would likely be effective in further reducing accident rates in coal mining. His insight into the limitations of the procedures was presented as an hypothetical case based on real past experiences.

Suppose the supervisors and crews on sections of one shift in a coal mine had adopted a behavioral safety intervention program much like the Komaki or Cohen and Jensen studies. Suppose all phases of the procedure had been properly implemented. The program is in place and is working well. Routine miner compliance with the targeted safety procedures has increased significantly over baseline, and accident and injury rates have declined. Suppose in this same mine, the section crews and their supervisors that work on another shift had not implemented the behavioral safety program or had not implemented it well. Suppose members of a maintenance crew on this shift had erected a temporary header across the main entry which the mantrip uses to enter the mine. The header reduces the clearance more than is safe. The maintenance crew inadvertently leaves the header in place, and fails to communicate this information to the next shift. Crew members on the next shift are entering the mine in a mantrip without a canopy. On the way in, a crew member's head strikes the unmarked beam and she is severely injured. The failure to communicate from one shift to another has caused a serious accident. Many mine accidents are of this type. The engineer concluded that no matter how effective and well implemented a specific behavioral safety intervention is for a particular section, it cannot work truly effectively unless there is a broader organizational commitment and involvement. Inter-crew and intra-crew interaction, mutual goal setting, and cooperation are required.

The specific targeted problem behaviors for each section also should not be the sole focus of the program. The hypothetical accident described by the engineer might not have occurred in this particular mine in recent years. The specific task of removing hazards or communicating their presence to members of the next crew might not have been targeted in a behavioral safety program. If workers attended only to the specific targeted tasks they would remain at risk to infrequent hazards that are not singled out for special attention. Simply put, the behavioral strategies are good for targeting and correcting specific problems, but miners and supervisors also need to continue to communicate, be perceptive to, and act to detect and prevent other potential hazards. Inter-crew attention to and communication of general hazard detection and correction can also be targeted, but this increases the complexity of the behavioral approach.

It is clear that the antecedent activities of behavioral safety programs need to develop proper organizational support from management, and to insure proper cooperation and communication across sections and shifts so that workers will remain alert to recognizing and correcting potential

hazards within and across sections and shifts. The organizational development studies of Trist et al. (1973, 1977) provide numerous good examples of how to foster such widespread organizational support and cooperation in these and similar situations. Even though behavioral safety procedures achieve much of their effectiveness by focusing on specific safety tasks in particular work sections, good safety programs also must attend to these organizational factors. Otherwise, they cannot achieve their potential effectiveness and are not likely to be properly implemented and institutionalized. Behavioral safety procedures are best thought of as a set of useful methods within a broader organizational and educational safety focus, not as "magic bullets" or quick fixes.

Activities that merit funding by the Bureau of Mines, the Mine Safety and Health Administration, unions, coal companies and/or other agencies are suggested in the remainder of this chapter. Two areas stand out as being potentially useful in extending the work in effective medical-health compliance and industrial safety interventions to coal mine safety. Other areas, like the characteristics of safe and unsafe mines, appear to have been well researched in a number of correlational and descriptive studies and require no further replications at this point. However, as mining technology, management practices, and characteristics of the workforce change, such replications might be worthwhile.

Cooperative Conceptualization of Safety Intervention Programs

It would be fruitful to fund an invited conference designed to convene representatives from the Bureau of Mines, coal companies and unions, the Mine Safety and Health Administration, and the National Institute of Occupational Safety and Health to meet with a select group of key academic researchers. The academic researchers would be those who have contributed most to the development and study of the methods for improving compliance with health and safety regimens in medicine and industrial health and safety.

The meeting should be designed to serve a number of objectives. A first objective could be for key persons in these fields to meet with one another and to become informed of the potential opportunity and value of applying well developed techniques known to be effective in boosting compliance with health and safety practices in other settings to coal mine safety.

A second objective would be to identify and discuss some of the key issues that arose in the 4 workshops presented as

part of this project. Included here would be discussion and clarification of issues like:

1. Who should or could do the behavioral observation of targeted miner behavior and why? What techniques should be used to collect such information and why?

2. What are the legal and ethical issues involved in using formal behavioral observations of percent of correct worker performance for informational feedback but not for enforcement of state and federal regulations? What problems may occur if such an approach is undertaken and how might these be overcome? To illustrate one issue, objective charts of medical care and patient response to the care are routinely used to provide medical staff and patients with informational feedback that is essential to assisting medical-health compliance behaviors. But such records are also frequently involved in legal malpractice suits. Are there similar problems in using specific behavioral observation and informational feedback in state and federally mandated safety procedures in coal mining?

3. In what ways can enforcement activities encourage and assist company commitment to augment general safety programs with more specific behavioral techniques? Should enforcement agencies do so?

A third objective for such a conference would be to develop guidelines that could establish policy for future expenditures in coal mine safety research in the behavioral-educational strategy realm.

A Course in Principles of Behavioral Safety Interventions

Behavioral safety program strategies like those reviewed in this report can probably be used by occupational task trainers and safety training officials to improve existing safety programs in coal companies. The improvements in miners' routine compliance with safety procedures might be expected to be on the same order of magnitude as observed in the experimental component analysis studies reviewed earlier. As Komaki, Barwick, and Scott (1978) demonstrated, a 20 to 25% increase in worker compliance with specific safe work practices (from a baseline of about 70% to a 90 or 95% level) can decrease injury rates by up to 80%.

It is recommended that the principles outlined in this report be developed as a short course. The course would be designed explicitly to review and demonstrate procedures that have proven to be effective in boosting compliance with

safe work practices in industrial work places. Course planning and development should jointly involve Bureau of Mines specialists, academics and researchers knowledgeable about the material contained in this report, MSHA personnel (perhaps at the National Mine Health and Safety Academy), and experienced occupational task and safety trainers from the coal industry in private companies and state enforcement and training agencies. A small group representing each of these areas could be convened to plan the details of the course after first reviewing this report, the materials used for the 4 regional meetings held in connection with this project, and other exemplary selected studies and materials, such as those shown in Table 6, sections 2.2 and 2.3.

Criteria for Course Development: The course should be planned to meet a number of criteria. First, it should build upon and incorporate the occupational task and safety training knowledge and skills participants would be expected to have already. The course would not propose the replacement of this prior knowledge with new principles. Rather, it would seek to equip the occupational task and safety trainer with new insights and skills to augment and strengthen his or her existing safety training activities. For example, companies using the occupational task training materials described by Krupp and Dahle (1984) would already have knowledge and experience in many aspects of behavioral safety program interventions. However, case studies that incorporate the empirically determined principles for boosting compliance with safe work practices described in the studies listed in Table 6, sections 2.1, 2.1, and 2.3 would likely be of interest to these company safety and occupational task trainers. Knowledge gained from review of these case materials (especially if coal mine examples wsere used) would allow these trainers to strengthen their existing programs and further boost compliance with proper and safe work practices.

Second, the course should consist of 2 or 3 parts. The first part would be an introduction to the purpose, objectives, and procedures. It would be designed to review the merits of behavioral safety program principles, provide clear practical examples and case studies of the methods in the context of coal mining, and allow the participants to apply the principles to coal mine safety problems similar to those they experience in their work. This first part of the course would equip trainers with basic knowledge and skills needed to apply the techniques to aspects of their local safety programs (e.g., target problem work tasks, develop appropriate observation and monitoring variables, forms, and observational procedures, determine base lines, develop feedback procedures, develop goal setting procedures for specific safe work practices, etc.)

A second part of the course might follow a few weeks after the first. It would be designed to allow the same participants to share their insights, frustrations, and ideas as they attempted to implement some of the principles learned in the first part. This second phase of the course would assist participants in tailoring and implementating the procedures to their needs. Participants' detailed sharing of ideas and information about their own mine sites, and analysis of these cases by small groups of trainers with similar problems or interests, might be planned. Session leaders might assist each member of a group to further implement selected principles into his or her own mine safety training program. In all cases the emphasis would be upon targeting specific safe work practices for purposes of boosting routine adherence of workers to the targeted safety procedures.

A third part of the course might follow within 3 to 6 months. It would be similar to the second phase of the program, but would require the participants to bring records of their implementation procedures, again for review and analysis in small groups of persons with similar interests. The primary purpose would be to assist institutionalization of the selected procedures at each site.

A third criterion is that the course should involve and train persons from a number of agencies, not only from coal companies. Rather, union safety officials and trainers, MSHA and state mining department personnel, as well as private mine safety instructors should be involved. The intention would be to develop an increased level of awareness and skill in using behavioral safety strategies to strengthen existing mine safety training programs.

A fourth criterion is that each part of the course be fairly short, perhaps no longer than one or two days duration. Each portion of the course could be conducted efficiently, especially if preparatory instructions and materials were mailed to participants earlier. The latter two parts of the course should require detailed preparation on the part of participants in order for them to gather the information needed from their own local sites for further study and analysis of their case situation at the "workshops."

A fifth criterion is that the first part of the course should stand alone. It should be sufficiently complete, well designed, practical, and motivating to encourage occupational task and safety trainers in attendance to immediately adapt and use some of the procedures and ideas presented. For this reason, it should provide a "take home" set of materials or handbook that would serve as a practical

guide to the implementation of the procedures. Participants who wished could continue in the following two workshops, but might also choose not to attend. In addition, those who missed the first class might study these materials and prepare to attend the second workshop.

A sixth criterion is that the first part of the course (and later portions as well) ought to be replicable at many sites, conducted by many different groups. Individual state mining education and enforcement agencies or other groups ought to be able to offer the course regionally.

A seventh criterion is that the course materials ought to be simple, inexpensive, easy to duplicate, and easy to use. It should be possible for the course to be taught with a minimum of special equipment. Well designed case study materials, illustrations, and examples could be presented in verbal, diagram, tabular, and graphic form on handouts and overhead projector transparencies. Short, motivating exercises and activities that demonstrate and/or illustrate the principles could be developed. Similar training materials are often developed, widely used, and can be effective (Cole, 1980; Kaurman, 1978, & Klaus & Jones, 1978).

Effectiveness of Similar Courses: Precidents for dissemination of new technologies to trainers and other professionals through similar short courses and workshops are numerous (Cole, Moss, Gohs, Lacefield, Barfield, & Blythe, 1984, Chapter 2; Klaus & Jones, 1978). Technical specialists in other fields acquire a major part of their knowledge and skill through similar short courses (Cole, et al., 1984, Chapters 1 and 3). At the University of Kentucky the Colleges of Allied Health, Commerce, Dentistry, Education, Engineering, Law, Medicine, Nursing, Pharmacy, Social Work, and others offer short technical courses with this type of format to thousands of technical personnel each year. Scores of other universities and agencies do the same.

Ease of Course Development: It would be relatively easy and inexpensive to develop such a course, in large part because this present study and its 4 regional workshops have already identified key principles, case study examples, and short summaries of these. What is needed are some additional case studies that illustrate how the principles could be applied to coal mine safety programs in a variety of situations. The course could best be developed by one or two persons with the guidance and assistance of the multiple agency planning group. The major costs to develop such a course would be funding a meeting or two for the planning group, paying for approximately 3 to 4 weeks of course material development by one or two persons, and typing and duplicating these materials. After the first few course replica-

tions, the materials should also be evaluated and revised. This activity may require another 3 to 4 weeks of effort by two persons. The first group of persons trained with the materials might include some who would be likely candidates for instructors for future course replications. These initially trained persons could use and modify the course materials as they instructed others at local or regional sites.

Additional Benefits: Developing and using such a course might stimulate additional well designed safety intervention studies like those listed in Table 6, sections 2.1 and 2.2, but carried out in coal mines. Toward this end some selected faculty from academic institutions, and other researchers with an interest in these types of problems, should be invited to participate in replications of the course along with other participants from the coal industry. There are always faculty members and graduate students at universities who are interested in carrying out research like the studies listed in Table 6, sections 2.1 and 2.2. In fact, studies like these are seldom carried out as fully as desirable unless academic researchers are involved. Likewise, when industrial personnel collaborate with researchers using actual problems in field based research, the studies tend to be of practical significance and the findings generalizable.

Such an arrangement would bring together academic researchers and coal industry personnel to examine how principles of behavioral safety programs, proven effective in other settings, might be applied to coal mining in order to lower injury rates by increasing routine adherence to safe work practices. Such a specific focus might be expected to stimulate more awareness and cooperation among these groups than would a more general topic or focus.

Two obvious areas for collaboration of academic researchers and coal industry personnel are: (1) the planning and implementation of behavioral safety intervention programs, and (2) the evaluation of the effectiveness of these programs in terms of multiple criteria including lowered injury rate, worker and management satisfaction, cost effectiveness, effects on production, safety training and retraining efficiency, and related outcomes. Cooperative field based research of this type could serve well both the coal industry and the academic community.

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APPENDICES

The appendix consists of 4 sets of materials. Appendix A is a description of the data bases listed in Table 1. This section provides information about the size, content, and other characteristics of each data base. Appendix B provides the actual search strategies used in various data bases except for the Index Medicus search and the NIOSTIC searches which are provided in Tables 2 and 3 in Chapter 2. Appendix C lists the experts from the coal industry who attended each of the 4 meetings where the project results were presented and discussed. There is a list for each meeting and the names are in alphabetical order. Appendix D is an outline of the 4 workshop sessions and a list of the questions discussed. It is nearly identical to the handout used for the first two meetings with industry experts.

Appendix A-Database Descriptions

Unless the source for an abstract included here is otherwise indicated, the abstract was adapted from Computer-readable databases: A directory and sourcebook, by Williams, Lannon, and Robins (1982) and published by the American Society for Information Science.

ABI/INFORM (Full Name)

This service includes a monthly publication from 1971 to present; 12 tapes per year. Subject matter and scope include all phases of management and administration with U.S. and international coverage. The number of items in the data base as of December 1981 was 158,000. The items are 100% journal articles of which 100% are in English. The number of journals entered including all articles is 170, the total number of journals reviewed for input is 500.

COAL DATA BASE (No Acronym)

The frequency of data base update is monthly. The time span included is 1976 to present. The number of updates issued is 12 per year. Subject matter and scope include all areas relevant to the coal industry including economics, policy and management, reserves and exploration, mining, coal preparation, transport and handling, coal properties and constitution, processing and conversion, combustion, waste management and environmental effects, products and utilization, and health and safety. The total number of items in the

database as of December, 1981 was 38,000. The items included are approximately 45% journal articles, 25% government reports and documents, and 30% monographs, published proceedings, theses, etc. The language of the material is French, German, Dutch, Russian, Bulgarian, Indonesian, Japanese, Rumanian, Swedish, Italian, Yugoslavian, Spanish, and English.

COMPENDEX (Computerized Engineering Index)

The frequency of data base update is monthly. The period covered is 1969 to present. The number of tapes issued per year is 12. The subject matter and scope included world wide coverage of significant engineering literature as found in journals, proceedings of conferences, symposia, technical reports of associations, government agencies, universities, laboratories, etc. The total approximate number of items in the data base as of December 1981 was 960,000. Approximately 55% are journal articles, of which 72.4% are in English; 5% are government reports and documents; 36% are monographs, published proceedings, theses, etc.; 3% are reprints of papers to conferences; 1% are miscellaneous others. Approximately 150 journals are totally included. The number of journal titles reviewed for input is 2,000. Language for the database source materials is primarily English (75%) and all other languages constitute the remainfrt (25%).

EDB (DOE Enerby Data Base)

The frequency of this data base publication is semimonthly. There are 24 tapes produced each year. The system was first available in machine readable form in 1974. It covers literature from 1880 to the present time. The subject matter and scope of data in the system includes international literature relevant to the various energy fields. As of December, 1981, the total number of items in the data base was 810,000. The languages of the data base materials are English, German, and Russian. Approximately 55% of the items are journal articles and 90% of these are in English. In addition to the journal articles, another 35% of the publications represented are government reports and documents, 5% are patents, and 5% are monographs, proceedings, theses, etc. The contents of approximately 3,000 journal titles are reviewed for inclusion.

ERIC (Educational Resources Information Center)

ERIC is updated monthly. It contains 493,500 citations dating from 1966 to present. It is the complete data base on educational materials, methods, research, and studies from the Educational Resources Information Center. The data base covers all areas of education including adult technical and vocational industrial education, health and safety education, and related fields. It consists of two main files: Resources in Education, which is concerned with identifying the most significant and timely education research reports and projects; and current Index to Journals in Education, an index of more than 700 periodicals related to the education profession. About 650 locations around the country have complete collections of ERIC microfiche, and most are open to the general public. (This abstract was taken from Dialog Information Retrieval Service Catalog, July, 1983.

GEOARCHIVE (No Acronym)

This data base includes two subset databases, Geomaps and Geoserials. It is updated weekly. The time span completely covered is from 1969 to the present time, although some very old (18th and 19th century) selected materials are included. The system became machine readable first in 1969. It provides selective international coverage on mineral and petroleum reserves. Approximately 6,000 journals are are reviewed of which 3,500 are totally included. The approximate number of items in the data base as of December 1981 was 7,000. Of these items, about 80% are journal articles (of that number, about 55% are in English). Another 4% are government reports or documents; 8% are monographs and published proceedings; 5% are preprints and reprints of conference papers; 1% are news items; and 2% are all other including maps. Most (79%) of the source materials are in English. Russian (7%) and French (4%) constitute the next largest numbers. Other Other languages make up the remainder (10%).

GEOREF (Geological Reference File)

The frequency of update on this data base is monthly. The period covered is from 1961 to the present time. The system became machine accessible beginning in 1967. Subject matter and scope of the data base include a wide subject spectrum of worldwide geosciences literature. Some examples of subjects included are geology, minerology, hydrology, petrology, oceanography, and marine geology. In 1981 there were approximately 700,000 items in the data base of which 78% were journal articles (of that number 70% were in English).

The remaining entries consist of government reports and documents, monographs, published proceedings, theses, etc., conference papers; maps, etc.. About 4,200 journals are reviewed for selected input and of those, 1250 are totally included. Data base source materials are from English, Russian, French, German, Spanish, Japanese, and Italian languages.

HSELINE (Health and Safety Executive)

This data base is updated monthly. It extends from 1977 to the present. It receives about 650 references per month and contains about 42,000 total references. About 250 periodicals are scanned. It contains references on research reports, legislation, monographs, and conference proceedings. It covers subjects of science, technology, manufacturing, production, agriculture, mining, explosives, engineering, nuclear technology, safety, environmental and industrial hazards. (This abstract was adapted from the European Space Agency Information Retrieval Services, July, 1983).

MEDLINE (Includes Index Medicus)

MEDLINE is updated monthly. It dates from 1966 to the present and contains 4,052,300 records. It includes Index Medicus, Index to Dental Literature, and International Nursing Index. It covers most subjects in the broad field of biomedicine. It indexes articles from over 3,000 international journals published in the United States and 70 other countries. Over 40% of recent (since 1975) additions contain authors' abstracts. Of the approximate 250,000 records added annually, about 75% are in English. (This abstract was taken from Dialog Information Regrieval Service Catalog, July 1983).

LABOR DOC (International Labour Documentation)

The frequency of issuing updates is monthly. The time span covered in this data base is 1965 to present. The subject matter and scope of this data base is worldwide coverage of labor questions, emphasis on industrial relations, labor law, employment, working conditions, vocational training, labor related aspects of economic development, technological changes, rural development, etc. The approximate number of items in the data base as of December 1981 was 110,000. The

total number of journals reviewed is 500. The bibliographic entries consist of journal articles (18%, of which 57% are in English); government reports and documents (17%); monographs, theses, proceedings, etc. (60%); conference preprints, reprints, and papers (5%).

MANAGEMENT (Management Contents Data Base)

Data base update is monthly. The timespan for the data base is 1974 to present. The first machine available data is 1977. The number of update tape issues per year is 12. The subject matter and content of the data base includes business, economics, management, accounting, advertising, banking, decision science, finance, marketing, and public administration. The approximate number of items in the data base as of December 1981 was 108,000. Bibliographic items are approximately 80% journal articles (of which 100% are English), 400 journal titles are reviewed for input. About 20% are monographs and published proceedings, theses, etc.

MINTEC (Mining Technology)

The time span covered by this data base is 1973 to present. The data base is not commercially available. There is no specified listing of tapes per year. Subject matter and scope of data base includes material on mining technology related to Canadian mining or generated in Canada. The number of items as of December 1981 was 24,000. Bibliographic data base items consist of approximately 60% journal articles. A total of 150 journals are reviewed for input. The breakdown of the other 40% of entries in the file is unknown. The languages of data base source materials are English and French.

NOISHTIC (National Institute for Occupational Safety and Health Technical Information Center)

This data base has monthly updates. The time span covered is 1880 to present. The first available machine readable form is 1973. This system is not commercially available. Subject matter and scope include world wide coverage of material related to occupational safety and health as well as information on industrial hygiene, epidemiology, engineering control, safety, biochemistry, toxicology, behavioral science, occupational medine, occupational safety and health education, and pathology. It also includes all pub-

lished and unpublished NIOSHA reports. The approximate number of items included in the system as of December 1981 was 84,000. Journal articles make up about 60% of the entries of which 85% are in English. The approximate total number of journal titles reviewed regularly for input is 200. The percentage of items that are government reports and documents is 25%, monographs, published proceedings, theses, etc., are 10%, 5% are reprints for conference papers. The language for data base source materials is English.

NTIS Bibliographic Data Base (National Technical Information Service Bibliographic Data Base)

The time span for this data base is 1964 to present. It was first available in machine form in 1970. The number of tapes issued each year is 26. The system has been commercially available from 1964 forward. Subject matter and scope of material in the data base includes multidisciplinary coverage of unclassified technical reports generated by government sponsored research. The approximate number of items in the data base as of December, 1981 was 810,000. The data base items are approximately 16% journal articles, of which 95% are in English, and 84% are government reports and documents.

PsychINFO (Psychological Abstracts Information Service)

Data base updates are (12) monthly, (4) quarterly, (2) semi-annually, and (1) annually. The timespan covered is 1967 to the present time. The system was first machine available in 1971. Subject matter and scope include non evaluative summaries of the world's literature in psychology and other behavioral sciences. The approximate number of items in the data base as of December 1981 was 365,000. The items are approximately 90% journal articles. A total of 1050 journal titles are reviewed for monthly input, other content includes 2% government reports and documents, 1% monographs, proceedings, etc., 1% reprints, and 6% other sources including dissertation and abstracts. Data base source material is in multiple languages, with English as the predominant language.

SOCIAL SCISEARCH (Social Science Citation Index)

This data base is updated monthly. It includes 1,238,200 records from 1972 to present. It is a multidisciplinary database indexing significant items from 1000 social science journals around the world and selected articles from an additional 2200 journals in the natural, physical, and biomedical sciences. It also includes many monographs. It covers every area of the social and behavioral sciences. (This abstract was taken from Dialog Information Retrieval Service Catalog, July 1983).

SOCIOLOGICAL ABSTRACTS (No Acronym)

Data base updates are bimonthly. Timespan covered is 1963 to the present. It was first accessible by machinery in 1972. The subject matter and scope of data in this data base includes international literature in sociology, social work, ethnology, law, statistics, policy sciences, etc. The approximate number of items in the data base as of December, 1981 was 113,000. The bibliographic entries include about 90% journal articles (55-65% in English). There are about 150 journals with all articles entered and 1250 journals reviewed for title input. The remaining entries consist of 1% monographs, published proceedings, theses, and 10% pre-prints of conference publications. Languages of data base are multiple.

Appendix B-Search Strategies

Search strategies developed specifically for particular data bases are included here. Strategies that are described for data bases in Chapter 2 are not repeated here.

ABI/INFORM

```
User 8727   Date: 1dec83   Time:12:30:25   File: 15

Set Items Description
  1   159 MINER? ?
  2  2394 COMPLIAN?
  3  1187 COMPLY?
  4   173 COMPLIE?
  5  3450  2-4/+
  6     3  1*5
  7  1031 ADHER?
  8     4  1*7-6
  9 23966 EMPLOYEE? ?
 10  9634 ATTITUD?
 11 13557 BEHAV?
 12  3914  9*(10+11)
 13   369 MINE
 14   335 MINES
 15  1277 MINING
 16  1645  13-15/+
 17  4053 SAFETY
 18  1773 ACCIDENT?
 19  2028 HAZARD?
 20  1544 INJUR?
 21  7347  17-20/+
 22     3  16*21*12
 23     3  22-6
 24 13320 INDUSTRIAL
 25  2315 OCCUPATIONAL
 26    26 AU=COHEN, A?
 27     0  16*26
 28     1  21*26
 29     1  26*9*(10+11)
 30     0 WORKPLACE(W)HAZARDS/TI
 31     0  28*99
 32   127  21*(1+16)*21-(6+8+23)
 33     5  32*(10+11)
 34     0  32*(4+7)-33

Print 6/5/1-2
Print 8/5/1-4
Print 23/5/1-3
Print 33/5/1
Print 33/5/4-5

Search Time:  0.133   Prints:  12   Descs.:  20
```

COMPENDEX

User14458 Date: 1nov83 Time:10:19:28 File: 8

```
Set  Items Description
  1      0 ACCIDENT(W)PREVEWNTION
  2   3839 ACCIDENTS
  3   8268 ACCIDENT
  4  15906 SAFETY
  5   1031 INJURY
  6    586 INJURIES
  7   7292 HAZARD?
  8   5930 ACCIDENT(W)PREVENTION
  9   2313 ATTITUD?
 10  62335 BEHAVIOR?
 11   1247 HUMAN(W)FACTOR?
 12   3553 HUMAN(W)ENGINEERING
 13   1150 PERSONNEL(W)TRAINING
 14   7330 BEHAVIOUR
 15      0 1AND11
 16   6392 COAL(W)MINE?
 17      0 ACCIDENT(W)PREVEWNTION
 18   3839 ACCIDENTS
 19   8268 ACCIDENT
 20  15906 SAFETY
 21   1031 INJURY
 22    586 INJURIES
 23   7292 HAZARD?
 24  27384  17 OR 18 OR 19 OR 20 OR 21 OR 2
 25   5930 ACCIDENT(W)PREVENTION
 26  27384 24OR25
 27   2313 ATTITUD?
 28  62335 BEHAVIOR?
 29   1247 HUMAN(W)FACTOR?
 30   3553 HUMAN(W)ENGINEERING
 31   1150 PERSONNEL(W)TRAINING
 32  69286  27 OR 28 OR 29 OR 30 OR 31
 33   7330 BEHAVIOUR
 34  74204 32OR33
 35   1088 16AND26
 36     38 35AND34

Print 36/5/1-38

Search Time:  0.154   Prints:  38   Descs.:  36
```

DOE

```
User14458   Date: 1nov83   Time:10:09:46   File:103

Set Items Description
  1 17727 COAL(W)MINE?
  2     0 ACCIDENT(W)PREVEWNTION
  3 22920 ACCIDENTS
  4  8535 ACCIDENT
  5 59848 SAFETY
  6  2016 INJURY
  7  5136 INJURIES
  8 20890 HAZARD?
  9 88772  2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 9
 10   188 ACCIDENT(W)PREVENTION
 11 88772 9OR10
 12  2139 ATTITUD?
 13 31626 BEHAVIOR?
 14   669 HUMAN(W)FACTOR?
 15    83 HUMAN(W)ENGINEERING
 16   174 PERSONNEL(W)TRAINING
 17 34239  12 OR 13 OR 14 OR 15 OR 16
 18 14141 BEHAVIOUR
 19 47447 17OR18
 20  4696 1AND11
 21   138 20AND19

Print 21/5/1-138

Search Time:  0.246   Prints: 138   Descs.:  19
```

ERIC

```
User38714   Date:20dec83   Time:13:58:26   File:  1

Set  Items Description
  1    362 MINING
  2    674 MINE?
  3     32 COAL(W)MINE?
  4    572 ACCIDENTS
  5    642 ACCIDENT(W)PREVENTION
  6    878 ACCIDENT
  7   5117 SAFETY
  8    425 INJURY
  9    537 INJURIES
 10   1008 HAZARD?
 11   7460  1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7
 12  63635 ATTITUD?
 13  58586 BEHAV?
 14    470 HUMAN(W)FACTOR?
 15     78 HUMAN(W)ENGINEERING
 16    323 PERSONNEL(W)TRAINING
 17 10684  12 OR 13 OR 14 OR 15 OR 16
 18      0 INDUSTRIAL OCCUPATIONAL
 19     75 WORK(W)PLACE
 20    334 WORKPLACE
 21    405  18 OR 19 OR 20
 22   9956 INDUSTRIAL
 23  18719 OCCUPATIONAL
 24     75 WORK(W)PLACE
 25    334 WORKPLACE
 26  27418  22 OR 23 OR 24 OR 25
 27   1614  (S3 OR S4 OR S5 OR S6 OR S7 OR
 28      2  S3 AND (S4 OR S5 OR S6 OR S7 OR
 29      8  (S1 OR S2) AND (S4 OR S5 OR S6
 30    522  S26 AND (S4 OR S5 OR S6 OR S7 O
 31      1  30/MAJ
 32   6590  S26 AND (S7 OR S5 OR S12 OR S13
 33    633  32/MAJ
 34    504  S26 AND (S5 OR S7) AND S17
 35      1  34/MAJ

Print 29/5/1-8

Search Time:  0.635   Prints:   8   Descs.:  28
```

NASA/RECON

SET	NO.	DESCRIPTION
1	35	41 ATL/MINER
2	23	23 ATL/MINERS
3	147	204 AX/MINER
4	38	43 AX/MINERS
5	1	1 AX/MINING *+1 PERSONNEL
6	183	248 3+4+5
7	215	312 6+(1+2)
8	1118	1118 ST/ACCIDENT PREVENTION
9	1377	1377 ST/HAZARDS
10	1577	1577 ST/SAFETY
11	340	340 ST/ACCIDENTS
12	1061	1061 ST/INDUSTRIAL SAFETY
13	4907	4907 8+9+10+11+12
14	12	18 7*13
15	624	688 ATL/COMPLIANC//COMPLIZA
16	4565	5176 AX/COMPLIANCE//COMPLICA
17	72	73 AX/COMPLIED //COMPLIES
18	13	13 ATL/COMPLY //COMPLYING
19	223	228 AX/COMPLY //COMPLYING
20	5185	6178 15+16+17+18+19
21	2	5 14*20
22	10	16 14-21
23	3297	3297 PSYCHOLOGICAL//PSYCHOLO
24	455	455 ST/EMOTIONAL FACTORS
25	75	75 ST/EMOTIONS
26	41	41 ST/MORALE
27	107	107 REINFORCEMENT//REINFORC
28	267	267 ST/INCENTIVES
29	332	332 ST/MOTIVATION
30	463	463 ST/BEHAVIOR
31	4551	4551 23+24+25+26+27+28+29+30=

NTIS

User 8727 Date: 1dec93 Time:12:22:31 File: 6

Set	Items	Description
1	725	MINER? ?
2	5158	COMPLIAN?
3	1576	COMPLY?
4	221	COMPLIE?
5	6010	2-4/+
6	18	1*5
7	1480	ADHER?
8	0	1*7-6
9	5392	EMPLOYEE? ?
10	13889	ATTITUD?
11	155209	BEHAV?
12	2693	9*(10+11)
13	5535	MINE
14	5248	MINES
15	18714	MINING
16	21684	13-15/+
17	59688	SAFETY
18	16447	ACCIDENT?
19	20210	HAZARD?
20	7711	INJUR?
21	76919	17-20/+
22	7	16*21*12
23	7	22-6
24	184402	INDUSTRIAL
25	10579	OCCUPATIONAL
26	136	AU=COHEN, A?
27	6	16*26
28	6	21*26
29	0	26*9*(10+11)
30	1	WORKPLACE(W)HAZARDS/TI
31	0	28*99
32	7	22-(6+30)
33	2941	(1+16)*21
34	293	INDUSTRIAL(W)PSYCHOLOGY
35	2	33*34-(32+6+23+30)
36	1	SOCIOPSYCHOLOGY
37	0	33*36-(32+6+23+30+35)

Print 32/5/3
Print 32/5/7
Print 35/5/1-2

Search Time: 0.250 Prints: 4 Descs.: 23

NTIS

User 8727 Date: 17apr84 Time: 10:46:13 File: 6

Set	Items	Description
1	863	COAL(W)MINE
2	1688	COAL(W)MINES
3	159	COAL(W)MINER? ?
4	2567	COAL(W)MINING
5	3967	1-4/+
6	17237	ACCIDENT?
7	62295	SAFETY
8	7951	INJUR?
9	21038	HAZARD?
10	80106	6-9/+
11	14152	ATTITUD?
12	159817	BEHAV?
13	295	PERSONNEL(W)TRAINING
14	14078	HUMAN(W)FACTOR? ?
15	173905	11-14/+
16	173	5*10*15
17	20	COALMIN?
18	3	10*15*17-16
19	5834	MINE
20	5586	MINES
21	799	MINER? ?
22	19868	MINING
23	23104	19-22/+
24	191	10*15*23-(16+18)
25	165449	11+12
26	129	5*10*25
27	3	17*10*25-(26)
28	155	23*10*25-(26+27)
29	8520	11+12
30	7	5*10*29
31	0	17*10*29-30
32	3	24*10*29-(30+31)
33	122	26-(27+30)
34	122	26-(30+32)
35	3	27-(30+32+34)
36	44	16-(34+35+30+32)
37	188	24-(36+34+35+30+32)
38	22955	COAL
39	317	ANTHRACIT?
40	2234	BITUMIN?
41	18	37*(38+39+40)

Print 30/5/1-7
Print 32/5/1-3
Print 34/5/1-122
Print 35/5/1-3
Print 36/5/1-44
Print 41/5/1-18

Search Time: 0.295 Prints: 197 Descs.: 26

PSYCHINFO

User 8727 Date: 1dec83 Time:12:07:17 File: 11

```
Set  Items Description
  1     65 MINER? ?
  2   1505 COMPLIAN?
  3    219 COMPLY?
  4     93 COMPLIE?
  5   1658  2-4/+
  6      1  1*5
  7    586 ADHER?
  8      0  1*7-6
  9   4615 EMPLOYEE? ?
 10  46300 ATTITUD?
 11 112075 BEHAV?
 12   2798  9*(10+11)
 13     54 MINE
 14     15 MINES
 15     60 MINING
 16    114  13-15/+
 17   1497 SAFETY
 18   1895 ACCIDENT?
 19    530 HAZARD?
 20   2144 INJUR?
 21   5399  17-20/+
 22      1  16*21*12
 23      1  22-6
 24   3936 INDUSTRIAL
 25  11265 OCCUPATIONAL
 26    116 AU=COHEN, A?
 27      0  16*26
 28      7  21*26
 29      0  26*9*(10+11)
 30      0 WORKPLACE(W)HAZARDS/TI
 31      5  28*99

Print 23/5/1
Print 31/5/1-5

Search Time:  0.317   Prints:   6   Descs.:  20
```

PSYCHINFO

User 8727 Date:14dec83 Time:15:33:03 File: 11

```
Set Items Description
  1    67 MINER? ?
  2   101 MINE? ?
  3    62 MINING
  4     0 COALMIN?
  5   160  1-4/+
  6  1920 ACCIDENT?
  7  1509 SAFETY
  8   534 HAZARD?
  9  2168 INJUR?
 10  5453  6-9/+
 11    22  5*10
 12    96 INDUSTRIAL(W)ACCIDENTS/DE
 13    84 OCCUPATIONAL(W)SAFETY/DE
 14  3967 INDUSTRIAL
 15 11362 OCCUPATIONAL
 16   150 WORKPLACE?
 17    58 WORK(W)PLACE? ?
 18    22  12*13
 19   158  12+13
 20 14941  14-17/+
 21     2  5*18
 22    10  5*19
 23    59  5*20
 24     0  21-11
 25     0  22-(11+24)
 26    44  23-(11+24+25)
 27 10422 STRESS
 28 14442 ANXIETY
 29  4915 FEAR
 30  4342 NEUROSIS
 31   864 NEUROSES
 32  5827 NEUROTIC?
 33 33429  27-32/+
 34     6  26*33
 35   370  10*20-(11+34)
 36    20  18-(11+34)
 37   128  19-(11+34+36)
 38   222 35-(36+37)
 39    12 E6-E7 AU=BUTLER, MAR
 40   134 AU=GUNDERS?
 41     0  39*40
 42    40 AU=JONES, AL?
 43   178  39+40+42
 44     0  5*43
 45   786 NAVY
 46    42 SAILOR? ?
 47    19 SEAM?N
 48     0 SEA(W)MAN
 49     0 SEA(W)MAN
 50   825  45-49/+
 51    98  43*50
 52    20  51*(19+20)

Print 34/5/1-6
Print 36/5/1-20
Print 37/5/1-128
Print 52/5/1-20
```

Appendix C

List of Coal Industry Experts

Names of Industry Experts who attended the session titled "Research on Individual Adherence to Safe Practices: Generalizations to Individual Miner Safety" are listed by location and date.

May 9, 1984 Charleston, West Virginia Department of Mines meeting

Name	Position	Organization
Berger, Philip	Professor	Univ. of Kentucky
Blakemore, A. H.	Training Director	West Virginia Department of Mines
Blevins, Kay C.	Inspector-at-large	West Virginia Department of Mines
Blythe, David	Associate Dean of Engineering	University of Kentucky
Clark, Dennis	Consultant	
Cole, Henry P.	Professor	University of Kentucky
Digman, Michael	Project Officer	United States Bureau of Mines, Pittsburgh
Ferrel, Joaquine	Inspector-at-large	West Virginia Department of Mines
Gillespie, Paul	Inspector-at-large	Department of Mines
Grear, L. E. Jr.	Assistant Inspector-at-large	New River Department of Mines
Hamilton, Chris R.		West Virginia Coal Association
Holt, Jack	Regional Manager for Safety	Consolidation Coal Company
Jordan, Albert	Asstistant Director	West Virginia Department of Mines
King, Grant	Inspector-at-large	West Virginia Department of Mines
Lay, Bart, Jr.	Deputy Director	West Virginia Department of Mines
Legg, Frank	Inspector-at-large	West Virginia Department of Mines
Miller, Walter N.	Director, Board of Health & Safety	West Virginia Department of Mines
Osborne, Terry	United Mine Workers of	

	America, Safety Representative	
Scott, Mark	Health and Safety Administration	West Virginia Department of Mines
Straight, Stephen A.	Safety Director	Upshur Coals Corporation
Varian, Joe	Union Carbine Union Safety Committee and, West Virginia Board of Coal Mine Health and Safety	
Wiehagen, William	Project Officer	United States Bureau of Mines, Pittsburgh

May 10, 1984 Beckley, National Mine Health and Safety Academy

Name	Position	Organization
Acord, Everett	United Mine Workers of America	Beckley, West Virginia
Adkins, James	General Manager for Safety	Cannelton Industries Charleston, West Virginia
Ayres, Anne	Research & Planning	Mine Safety and Health Administration Academy
Berger, Philip	Professor	University of Kentucky
Blythe, David K.	Associate Dean of Engineering	University of Kentucky
Cole, Henry P.	Professor	University of Kentucky
Digman, Michael	United States Bureau of Mines	Pittsburgh
Farley, Donald	District training Specialist	Mine Safety and Health Administration
Forte, John	Education Specialist	Academy
Harrison, Douglas	Chief, Industrial Hygiene Branch	Academy
Hymes, John	Chief General Studies Branch	
Johnson, Jerry		Academy
Krese, James	District Manager	Mine Safety and Health Administration
Mason, Ronald M.	Director, Program for	Southern Illinois

	Participatory and Cooperative Workplaces	University
Maxwell, Wayne		Academy
McEnerney, Charles	Student	Southern Illinois University
McCoy, Kenneth	Director of Health and Safety	Amherst Coal Company
Nacey, Ed	Dean of Academic Affairs	Academy
Plaisted, Alynn		Westmoreland
Proffitt, Clyde	Training Specialist	Academy
Sanders, John	Director, Human Resources	Island Creek
Scaggs, Ronald	District Supervisor Safety and Training	Pickands-Mathers
Scott, Kenneth		Academy
Sutton, Ireland B.		Valley Camp Company
Wiehagen, William	Project Officer	United States Bureau of Mines
Woelflin, Les	Mine Safety and Health Administration	Academy

June 8, 1984 Kentucky Department of Mines and Minerals, Jenny Wiley State Park

Auvenshine, Dwight	Professor	University of Kentucky Lexington, KY 40506
Baker, Bobby		Box 34 Combs, KY 41729
Berger, Philip	Professor	University of Kentucky Lexington, KY 40506
Bentley, Bobby		Box 595 Neon, KY 41840
Cameron, Forrest		Morehead State Univ. Morehead, KY 40351
Clayton, William E.		P. O. Box 680 Lexington, KY 40586
Cole, Henry	Professor	University of Kentucky Lexington, KY 40506
Daltes, Bernard	Martin Co. Coal Corp.	Inez, KY 41224
Dixon, Bob	Martiki Coal Corp.	Lovely, KY 41231

Dupree, Kenneth		1516 Lomond Rd. Madisonville, KY 42431
Gable, Norman	Mining Instructor	HC #70, Box 255 Prestonsburg, KY 41653
Gregory, Ralph		Box 174 Manchester, KY 40962
Harvard, John D.		Box 1404 Harlan, KY 40831
Johnson, David L.	Elect. Instructor	Box 79 McRoberts, KY 41835
Justice, Archie	Mining Instructor	Hi Hat, KY 41636
Kidd, Raymond		Box 64 Drift, KY 41619
McDowell, Ronnie		117 Tall Oak Trail Pineville, KY 40977
Meyer, Karl J.	Mine Safety Instructor	Box 2971 Pikeville, KY 41501
Moore, Arthur		HC 85, Box 365 Garrett, KY 41630
Polley, Granville	Mining Instructor	768 Plainview Madisonville, KY 42431
Rice, William	Mining Instructor	Rt. 5, Box 206N London, KY 40741
Riley, Austin	Mine Inspector	Rt. 1, Box 268 Island, KY 42350
Shelton, Jack	Elect. Mining Inst.	560 Bailey Drive Madisonville, KY 42431
Wiehagen, William	Project Officer	United States Bureau of Mines

May 30, 1984 National Academy for Mine Health and Safety, Beckley, West Virginia

Bell, Ewing R.	Training Specialist	MSHA Pittsburgh District 2
Berger, Philip	Professor	Univ. of Kentucky

Blythe, David	Assoc. Dean, Engineering	Univ. of Kentucky
Bradbury, Raymond A.	President	Martin Co. Coal Corp.
Childress, Harry D.	Chief	Virginia Division of Mines
Cole, Henry	Professor	Univ. of Kentucky
Davidson, Harold	Safety Committee	UMWA, Local 1509
Fegan, James A.	Plant Supt., Tilden Mine	Cleveland Cliffs Iron Co.
Goss, Columbus A., Jr.	Safety Committee	UMWA, Local 1509
Grasso, John T.	Research Associate for Research & Development	W. Va. University
Howard, John	Instructor Coal Mining Tech.	Wabash Valley Col.
Hunter, Louis	Exec. Vice President	NICOA
Klishis, Mike	Professor, Mining Extension Service	W. Va. University
Lawrence, Roger	Tech/Safety	Ensign Bickford Co.
Misagi, Leo	Chairman Res. Ed. Dept.	MSHA Academy
Nacey, Ed	Academy Staff	MSHA Academy
Nehrebecki, Myron		R & P Coal Co. 655 Church St. Indiana, PA 15701
O'Quinn, Sherman H.	Safety Committee	UMWA Local 1509
Osnun, Roger	Manager, Tech. Services	Ensign Bickford Co.
Reese, Charles D.	Dist. Trng. Specialist	MSHA, Morgantown, W. Va.
Stearns, Howard	Instructor (CMT)	Wabash Valley College
Utley, Thomas R.	Director H. R. Plng. & Dev.	Peabody Coal Co.
Wallace, Kermit	Safety Committee	UMWA
Weir, David	Safety Director	Rogers Group, Inc.

Woods, George	Southern Supervisor	Wabash Valley College
Zegeer, David A.	Director	MSHA

APPENDIX D--Handout for Sessions with Industry Experts

Outline for Session

Purpose: What can you teach us to help make our recommendations for the project report to USBM more meaningful and useful?

Nature of our research: Can what is known about increasing persons' compliance with health and medical advice be useful in designing safety programs to increase compliance with safety practices?

Compliance defined: To comply means to follow a rule or procedure. Compliance is defined as the degree to which a person follows a prescribed health, medical or safety procedure to reduce risk of injury.

Limitations of this research: The three Es are essential to mine safety:

Engineering
Enforcement
Education

This research speaks only to education. It offers ways to make education more effective in boosting compliance with safety practices. It does not replace engineering and enforcement.

Principles for boosting compliance with health and safety practices: A few common principles will be outlined and discussed.

Case studies: A few case studies illustrate how effective principles in the medical and health compliance area can be applied to industrial and mine safety.

Three approaches to safety programs: Their characteristics and effectiveness

Organizational
Educational
Behavioral

{Which is most effective and why?
{What is the optimum use of all 3?

Discussion topic: Can these principles be applied to underground coal mining safety programs? Problems and prospects from your perspective.

Specific Questions for Discussion

1) Could the principles outlined here be used to increase the percent of correct performance of specific tasks in coal mines to improve safety?

2) What particular tasks in coal mining might be targeted for improved compliance with specified safety practices?

3) How would miners and their supervisors respond to such attempts?

4) Why have studies like those described not been done in coal mining?

5) If these types of approaches were to be used in underground coal mining, what might have to be done differently, and why? Who should do the observation of worker behavior on specific tasks? How could random observations be arranged? Where and how should the results be posted?

6) In what ways might such approaches be institutionalized into ongoing safety programs as opposed to being seen as short term projects or experiments?

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