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The three factor accident prediction inventory

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THE THREE FACTOR ACCIDENT PREDICTION INVENTORY

by

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VITA

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CHAPTER I

INTRODUCTION

Each year, many people are injured while on the job resulting in millions of dollars in losses. These losses include direct costs for medical and disability payments and indirect costs which include increased payroll expenses to cover the injured worker's position, increased insurance premiums, and lost revenues due to decreased productivity.

By identifying the factors which increase accident frequencies and severity, one should be able to identify the employees that have a greater possibility of being involved in work related accidents. It is important to remember that a person's accident potential is a complex interaction between their work environment, their work habits, and the nature of their job task. Using the underlying interrelationship of these factors, one may be able to predict the employee's accident potential with a series of questionnaire items. Organizations may also be able to identify the need for accident prevention techniques like safety training, safety policies, and safe job procedures. When implemented, these programs may be effective in reducing an organization's accident frequency and severity rates.

Accident Causation Theories

Many theories have been proposed which attempt to describe the causes of accidents and injuries. One of the first accident causation models was developed by H.A. Heinrich in 1931. Heinrich's theory states that a series of events which, when allowed to occur in sequence, will result in an accident. In order to prevent the accident, one of the steps in the sequence must be removed. This "domino theory" of accident causation was the earliest and one of the simplest models used for describing what has now become considered a very complex interaction between the worker and the work environment.

Heinrich also established a theory which relates the causes of accidents to either unsafe acts or unsafe conditions. Studies performed on work related injuries found that as much as 85 percent of all work related accidents are caused by unsafe acts while the remaining 15 percent are due to unsafe conditions.[1]

Employee Factors

The preceding theories have based the cause of accidents on a human and environmental interactions. Since the majority of accidents are caused by unsafe acts, human action can be considered the primary cause for accidents.

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[1]Herbert Heinrich, Industrial Accident Prevention, (New York: McGraw Hill, 1931).

The following accident theories examine the human element of accidents.

Risk Taking Behavior. To gain a better understanding of unsafe actions, one must examine risk taking behaviors in workers. The term "risk" in this study pertains to a degree of danger in relation to the decisions being made. Risk is, therefore, defined as the expected loss of an alternative to be chosen.[2] This definition concentrates on the decision making process and not only the outcome.

In the decision theoretic model, risk is described in relation to the acting person. In a certain situation, a worker makes a choice from a number of alternative actions such that the gain is maximal and the loss is minimal. By taking the information that is at hand, the person will be able to reduce the uncertainty about the expected outcome of each possible action he could choose. Risk, then, is the expected loss if a particular action is chosen given the information available.[3]

Even when provided with information about hazards and what actions must be taken to prevent accidents and

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[2]S. Oppe, "The Concept of Risk: A Decision Theoretic Approach," Ergonomics 31, No. 4 (1988): 435.

[3]S. Oppe, 435.

injuries, people still take risks. The unsafe behavior may be unknown, in situations when the employee does not have information needed to prevent the accident or has been provided incorrect or incomplete information. Still others will act unsafely despite the fact that all information has been provided.

Theories have been developed which may be used to define psychological constructs that predispose a person to taking more risks than others by failing to follow safety policies, procedures, and rules. One of these theories is the Internal-External Locus of Control theory.

Locus of Control Theory. The Internal-External Locus of Control theory, developed by Julian Rotter in 1966, was one of the first psychological construct theories examined as a possible predictor of accident potential. Rotter theorized that the effect of a reinforcement following some behavior on the part of a human subject is not a simple "stamping-in" process but depends upon whether or not the person perceives a causal relationship between his own behavior and the reward. A perception of causal relationship need not be all or none but can vary in degree.[4]

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[4]Julian Rotter, "Generalized Expectancies for Internal Versus External Control of Reinforcement," Psychological Monographs: General and Applied 80, No. 1 (1966): 1.

The locus of control is a construct reflecting belief or perception about who controls behavior and life events. Belief in personal control is both a general predisposition that influences behavior across a wide range of situations and a rather specific set of beliefs that may apply to a more limited situation.[5]

When a reinforcement is perceived by the subject as following some action of his own but not being entirely contingent upon his action, then it is typically perceived as the result of luck, chance, fate, as under control of others, or as unpredictable because of the great complexity of the forces surrounding the person. When the event is interpreted in this way by the individual, we have labeled this a belief in external control. If the person perceives the event contingent upon his own behavior or his relatively permanent characteristics, we have termed this a belief in internal control.

Safety Program Factors

Safety, loss control, and accident prevention are major functions in the workplace. Safety policies and procedures are implemented to attain the goals of reducing accident frequencies and reducing accident severity. These programs establish and reinforce the behaviors required

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[5] S. Connolly, "Changing Expectancies: A Counseling Model Based on Locus of Control," Personnel and Guidance Journal 59 (1980): 176-180.

thus reducing the influence of the external locus of control construct upon the workers' behavior.

Safety Policies and Procedures. There are safety policies and procedures which can be implemented in an organization to reduce accident frequencies and severity. These policies and procedures deal with everything from employee training to claims management techniques.

Safety Training. Safety training is another important aspect of behavior modification designed to control the possible adverse effects of unsafe acts. Research has been conducted which supports this idea. Employees are taught safe methods for performing job tasks and then are expected to follow them. However, despite knowing the safe procedures, some employees will still take risks thus increasing their potential for being involved in an accident.

Predictive Inventories

Predictive inventories may be useful in assessing worker accident potential. Inventories have been developed that use the locus of control theory as the underlying construct for predicting a worker's potential for following safety rules and safe job procedures. It is believed that inventories have not been developed which examine both the employee and the safety program influence together. This employee and work environment interaction may be very important in predicting work related accidents accurately.

Employee Safety Inventory

The Employee Safety Inventory consists of seven different scales designed to measure the likelihood that an individual will engage in safe behaviors and avoid on-the-job accidents.[6]

The Safety Control Scale assesses whether an employee will assume responsibility for job safety and accident prevention. This scale is based on the locus of control theory. The Risk Avoidance Scale assesses whether the employee has tendencies to engage in high risk activities and the Stress Tolerance Scale measures the individual's on-going experience with stress and the ability to withstand stress.

Two validity scales determine the extent to which the employee tried to answer the questions in a socially desirable manner and if the employee understood and answered the inventory carefully. The Safety Index provides a quick reference to the employee's overall safety

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[6]Michael Boye, Joy, Dennis, Slora, Karen, and Jones, John "The Relation of the Employee Safety Inventory to Driving Accidents and Related Costs at a National Trucking Company," ESI Research Abstract (Park Ridge, IL: London House Publishers) No. 13 (1990): 1.

attitudes and fit into a particular safety-sensitive position. The final scale, the Driver Attitudes Scale is a supplementary scale that assesses an individual's likelihood for regularly engaging in safe driving practices.

The Employee Safety Inventory can be used as a survey of current employees to identify training needs as part of an organizational risk assessment.[7] The inventory can also be used to identify individuals at risk for on-the-job accidents and to determine safety training needs.[8]

Safety Locus of Control Scale

The Safety Locus of Control Scale is one scale of the Employee Safety Inventory. This scale has been studied to some extent with regards to accident causation.

The Safety Locus of Control Scale is a seventeen item scale. The items are comprised of ten externally oriented and seven internally oriented statements. Eleven items make references to industrial accidents and six make references to accidents in general. A six point Likert-type scale was used for each item ranging from agree very

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[7]Boye, Joy, Slora, and Jones, 1.

[8]Karen Slora and John Molcan "Psychological Organizational Risk Assessment: A Case Study," Paper presented at the American Psychological Association/National Institute for Occupational Safety and Health (APA/NIOSH) Conference, "Work and Well Being: An Agenda for the 90's", Washington, D.C. (1990).

much to disagree very much. Validation of the Safety Locus of Control Scale was found to be effective in differentiating between contrasting groups with different accident histories.[9]

A few studies have been performed which suggest that internal scorers are more likely to be safety conscious than external scorers.[10] Internally oriented individuals place responsibility of accidents on themselves whereas external people place the blame of an accident to uncontrollable factors such as luck, chance, fate, or powerful others.

Summary

Work related accidents are the result of a complex interaction between the employee and the environment. The manner in which a person processes the information at hand and subsequently uses it to follow or choose not to follow safe job procedures, may be the key to determining the potential for being involved in an accident. The Locus of Control theory may play an important role in describing the

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[9]John Jones and Lisa Wuebker, "Development and Validation of the Safety Locus of Control Scale," Perceptual and Motor Skills 61 (1985): 151-161.

[10]H. Wichman and J. Ball, "Locus of Control, Self-Serving Biases, and Attitudes Towards Safety in General Aviation Pilots," Aviation, Space, and Environmental Medicine 54 (1983): 507-510.

underlying constructs which predict unsafe actions and ultimately accident involvement.

Because the environment plays an important role in determining the potential for accident involvement, it must also be examined in order to predict the overall accident potential for an employee.

In a given situation, two employees are required to perform the same job task at two different organizations. Because the job tasks are the same, the influences of the job hazards are removed. The first employee may have strong internal attributions and the organization may have a weak safety program. The second employee may have strong external attributions but the organization may have a strong safety program. The external employee may have a much lower accident potential than the internal employee because the safety program has effectively removed the environmental factors that increase the employee's potential for an accident more so than what an internal locus of control construct can do by reducing unsafe acts.

Currently, the predictive scales available only examine employee traits and neglect to measure the influences that a safety program has on offsetting potentially hazardous effects of the employees' locus of control.

Problem Statement

Occupational injuries are caused by an interaction between the worker's locus of control and the work environment. The safety program can greatly influence the accident frequency and severity from one location to another thus contaminating the predictability of accident involvement through the use of the locus of control construct. Currently, there is no inventory available which uses the locus of control construct and incorporates the influence that various safety programs have upon accident frequency and severity. By developing such a scale one may be able to predict occupational accident frequencies and severity very accurately. Then, by identifying those employees that are classified as high accident frequency and severity potential, proper safety training and programs can be developed and directed toward those employees that would benefit from them the most.

The purpose of this study is to develop a valid and reliable inventory for predicting work related accident frequencies and severity. The employee's general locus of control construct, the employee's safety locus of control, and the influence of the organization's safety program will be used to develop an inventory that can predict accident frequencies and severity. Therefore, this inventory has been named "The Three Factor Accident Prediction Inventory".

Basic Assumptions

1. It is assumed that the random sampling of the subjects was a true representation of the population with no selection bias.
2. It is assumed that the random sampling of the organizations was a true representation of the population with no selection bias.
3. It is assumed that all respondents answered all of the questions truthfully and to the best of their knowledge.
4. It is assumed that the information obtained from the locations about the presence and implementation of safety programs is correct.

Limitations of the Study

1. The reliability of the scales will be measured using a split-half method. Reliability for the entire accident prediction instrument through the use of a test-re-test method is beyond the scope of this study.
2. This Inventory is limited to predicting work related accident involvement in the park district setting. However, the methodology followed in this study can be used to develop inventories in any type of work setting.

Definitions of Terms

1. Accident: For the purpose of this study, an accident is defined as an event that results in a workers' compensation claim filed with the Park District Risk Management Agency during the time period of January 1, 1990 thru December 31, 1992.
2. Accident Severity: Accident severity will be measured as total experience in dollars paid or reserved for each claim filed.
3. The Three Factor Accident Prediction Inventory: This instrument has been developed by the author of this study. The instrument consists of two scales. They are the Employee Locus of Control Scale and the Safety Program Influence Scale. The items were first developed in a pilot study conducted from January to July 1992.

CHAPTER II

REVIEW OF LITERATURE

This study will examine The Three Factor Accident Prediction Inventory's ability to discriminate between accident and non-accident involvement and the Inventory's ability to discriminate between three levels of accident severity. The Inventory was developed by the author in a 1992 pilot study and is based upon three major factors. These factors are a general locus of control construct, an accident locus of control construct, and the influence that various safety programs have upon accident frequencies and severity.

The review includes studies that confirm the existence of the locus of control construct, its relationship with accidents, and the ability to measure the locus of control construct with inventories. This study appears to be the first to combine the locus of control construct with the influence of the safety program in a predictive inventory to measure both accident involvement and severity.

Locus of Control and Accident Causation

The locus of control theory states that people generally internalize or externalize the causes for events that occur to them. Since Rotter first published his Internal-External Locus of Control Scale in 1966, successful research has been performed which relates this construct with occupational accident involvement.[11, 12, 13]

The initial use of the locus of control construct was for identifying depression in patients. The inventory measures the degree to which a person internalizes or externalizes events that occur in their lives. Persons with an internal locus of control believe that the events that happen to them are the direct result of their own actions. Persons with an external locus of control do not believe that they have such control; one would surmise that external locus of control persons would believe that accident involvement is a matter of luck.[14]

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[11] Lisa Wuebker, "Safety Locus of Control as a Predictor of Industrial Accidents," Journal of Business and Psychology 1 (1986): 19-30.

[12] John Jones and Lisa Wuebker, "Development and validation of the Safety Locus of Control Scale," Perceptual and Motor Skills 61 (1985): 151-161.

[13] John Jones and Karen Slora, "Predictive Validation Study of the Safety Control Scale," ESI Research Abstract No. 1 (Park Ridge, IL: London House Publishers) (1988).

[14] Herbert Lefcourt, Research with the Locus of Control Concept I (New York: Academic Press, 1981): 33.

Research has been performed which examines the relation between this locus of control concept and accident involvement. According to theory, there is some evidence that internals who have been involved in accidents see themselves as contributing to causes of the accident more often than do external persons who were also involved in accidents.[15]

Sims, Graves, and Simpson[16] cited several studies where locus of control scores were related to perceptions of risk and responsibility in other types of situations.

In studies with traffic accidents, performed by Guastello & Guastello, no direct relation was found between the Rotter Locus of Control Scale and the accidents. The locus of control factor only represented a generalized attributional style.[17]

A study was performed by Sosis to investigate the effects of internal-external control upon a perceiver's

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[15]Elaine Foreman, Haydyn Ellis, and Diane Beavan, "Mea Culpa? A Study of the Relationship Among Personality Traits, Life Events, and Ascribed Accident Causation," British Journal of Clinical Psychology 22 (1983): 223-224.

[16]M. Sims, R. Graves, and G. Simpson, "Mineworkers' Scores for the Rotter Internal-External Locus of Control Scale," Journal of Occupational Psychology 57 (1984): 327-329.

[17]Steven Guastello and Denise Guastello, "The Relation Between the Locus of Control Construct and Involvement in Traffic Accidents," Journal of Psychology 120 (1986): 293-297.

attribution of responsibility to a defendant in an automobile accident.[18] Results showed that the people who believe they are largely in charge of their own fate, appear to have extended this same notion to others and then judged responsibility according to this notion. For internals, people who feel that they have control over their own fate, a person that does a bad deed is responsible for the effects for that bad deed. For externals, people who feel they don't have full control over their own fate, seem to extend this lack of control to others. For externals, if people do not reign over their fate, then a person who commits a negative act is not necessarily responsible for the results of that act.

Studies have concluded that most accidents arise from human error.[19] Because human error is the underlying basis for accidents, the locus of control construct has been studied as one of many psychological traits that may predispose people to human error and ultimately accident involvement. Foreman, Ellis, and Beavan concluded from their work that the psychological measure most predictive of an accident behavior involved the subjects' belief about

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[18]Ruth Sosis, "Internal-External Control and the Perception of Responsibility of Another for an Accident," Journal of Personality and Social Psychology 30 (1974): 393-399.

[19]A. Feggetter, "A Method for Investigating Human Factor Aspects in Aircraft Accidents and Incidents," Ergonomics 25 (1982): 1065-1075.

locus of control.[20] Findings concluded that internals who had been involved in auto accidents saw themselves as contributing to causes of the accident more often than did external persons who were also involved in accidents.

Besides making differential attributions about the accidents, internals and externals appeared to arrive at different interpretations of the accident. For internals, it was a case of negligent behavior; for externals, it was a case of bad luck. There are two possible reasons why internals and externals come up with a different construction of the same situation. First, the two groups may have differed in their perceptions of the constraints operating in the situation. Second, both groups might have perceived the same factors operating in the situation but assigned different weights to the various perceived factors.

The literature review has identified extensive research which used the locus of control theory as an underlying construct for occupational and automobile accident involvement. In some cases, the locus of control construct was found to be predictive of accident involvement while some studies did not reach this same conclusion.

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[20] Foreman, Ellis, and Beavan, 223-224.

The mixed results from studies indicate that there may be confounding variables that also influence accident involvement. It is believed that safety programs greatly influence accident involvement and may counteract the effects that an external locus of control may have in accident potentials. As will be discussed in the 1992 Pilot Study section of this chapter, by combining scores that measure the impact of various safety programs with the locus of control construct, it may be possible to develop an instrument that is capable of predicting accident involvement.

Locus of Control Based Inventories

Researchers have developed psychological instruments intended to measure the subjects' loci of control. With the proposal of the internal-external locus of control model, Phares, in 1957, first developed a Likert-type scale with 13 items stated as external attitudes and 13 items stated as internal attitudes.[21] Rotter along with Seeman and Liverant undertook to broaden the test and develop subscales for achievement, affection, and general social and political attitudes. The subscale areas tended to correlated highly with other scales at approximately the same level. Items designed to measure the more specific

[21]Rotter, 1-28.

subareas were abandoned. The final version of the scale consisted of 29 forced choice items.

Many studies were performed with the final scale including factor analyses. In 1963, Franklin factor analyzed 1000 cases and identified a general factor which accounted for 53% of the total scale variance.[22] Rotter concluded from his studies that validity of the I-E Scale came from the predicted differences in behavior for individuals above and below the median of the scale or from correlations from behavioral criteria.[23] Rotter further stated that internal people are more likely to (a) be more alert to the aspects of the environment which provide information for future behavior; (b) take steps to improve environmental condition; (c) place greater value on skill or achievement reinforcements and be generally more concerned with ability, particularly his failures; and (d) be more resistive to subtle attempts to influence.

Employee Safety Scale

The Employee Safety Scale is an accident prediction inventory based upon the locus of control theory. The Employee Safety Scale, is one of seven scales found on the Employee Safety Inventory published by London House. The

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[22]Rotter, 1-28.

[23]Rotter, 1-28.

Employee Safety Inventory is comprised of the Safety Control, Risk Avoidance, Stress Tolerance, Validity Distortion, Validity Accuracy, Safety Index, and the Driver Attitudes Scales.

For the purposes of this study, the Safety Control Scale is of most importance. The Safety Control Scale measures the likelihood an individual will assume the responsibility for having an on the job accident. This scale is a measure of safety consciousness and is based on the locus of control construct. The Employee Safety Control Scale has been widely studied. This scale, which was developed by Jones in 1983 and first appeared as a scale in the Personnel Selection Inventory in 1988, has been shown to be predictive of workers' compensation losses.[24]

Studies have also found that low risk employees had significantly higher Safety Control Scale Scores than the high risk employees ($P<.01$).[25] The safety control scores were significantly related to a number of work-safety related criteria, including work accident histories, urinalysis results, unsafe driving practices, and insurance claims to name a few.[26]

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[24]Jones and Wuebker, 151-161.

[25]Jones and Slora, 1.

[26]Karen Slora and Alison Bocian, Employee Safety Inventory (ESI): Reliability and Validity Summary (Park Ridge, IL: London House, 1991).

Studies with this instrument have shown that the MMPI General Social Maladjustment Scale, the Distractibility Scale, and the total MMPI derived items had correlations of .41, .56. and .57 (P<.001) respectively for all three scales.[27] In studies involving accident histories correlations of .39 (P<.01) were obtained when comparing employees with no work related accidents in the past five years and employees with 20 or more accidents in the past five years.[28]

A study in 1985 by Jones and Wuebker obtained a Chi Square Coefficient of 8.5 (P<.05) when comparing scores obtained on the scale and accident involvement with college students and accident involvement. The cases were categorized as no accidents, minor accidents, and major accidents.

Internal reliability studies on the Safety Control Scale yielded positive results. Chronbach's Alpha was used to test this reliability. As for the validity of the Safety Control Scale, a study examined the relationship between two other accident related personality scales and

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[27]Karen Slora, Michael Boye and John Jones, "Construct Validation Study of the Employee Safety Inventory," ESI Research Abstract No. 3 (Park Ridge, IL: London House Publishers, 1988).

[28]Fred Rafilson and Kathy Rospenda, "Concurrent Validation Study of the Safety Scale," ESI Research Abstract No. 5. (Park Ridge, IL: London House Publishers, 1988): 1.

accident criteria. A reliability coefficient of .89 (N=380) was obtained.[29]

Studies described in the literature review have shown that a relationship does exist between accidents and the internal-external locus of control construct.

1992 Pilot Study Findings

A pilot study was undertaken by the author of this study to identify factors which can be used in an instrument that is effective in predicting work related accident frequencies and accident severity. Rotter's Locus of Control Theory and the Attribution Style Theory were explored as possible underlying constructs that predispose workers to accidents. These constructs, along with the safety program components and job risk levels, as measured using Hammer's formula[30], were believed to be factors which influence accident involvement and severity.

Subjects were selected from organizations that are members of Park District Risk Management Agency (PDRMA), a self insurance pool for 110 park districts, special

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[29]Michael Boye, Karen Slora, and John Jones, "Reliability of the Employee Safety Inventory," ESI Research Abstract No. 7 (Park Ridge, IL: London House Publishers, 1989): 1.

[30]Willie Hammer, Handbook of System and Product Safety (Englewood Cliffs, NJ: Prentice Hall, Incorporated, 1972).

recreation associations, and forest preserve districts in Illinois.

Prior to the study, it was believed that the subjects' locus of control, the job risk level, and the safety program would be effective in predicting workers' compensation claims history.

An Accident Locus of Control Scale was developed using questions that were modeled after Rotter's Locus of Control Scale. The new questions on the Accident Locus of Control Scale dealt only with accident related situations. This procedure was also followed when constructing the Accident Attribution Style Questionnaire from the Attribution Style Questionnaire.

Discriminant analyses were performed on the Accident Locus of Control Scale and Rotter's Locus of Control Scale to determine their ability to discriminate between accident and non-accident cases. Initial analyses using only the Accident Locus of Control Scale did not discriminate well for accident cases.

It appeared that answers obtained on the Accident Locus of Control instrument were biased. Some workers that had been involved in worked related claims answered the items in a manner that would be considered "desirable". The Rotter Locus of Control Scale was predictive but not to a substantial level for non-accident cases.

Overall, the results suggested that internally based beliefs about the control of bad events and internally based beliefs about accident prevention and causation were more strongly associated with non-accident cases. A combination of both Rotter's Locus of Control Scale and the Accident Locus of Control Scale was necessary in order to discriminate between accident and non-accident cases at high levels.

The Attribution Style Questionnaire and the Accident Attribution Style Questionnaire were not predictive of accident involvement. Discriminant analyses on the scale items were not possible due to the procedures used to derive scores on the instruments.

The park districts' safety programs are evaluated annually by the PDRMA risk pool. The items from the annual evaluation were used to construct the Safety Program Scale. Some items from the Safety Program Scale were capable of discriminating between accident and non-accident cases, however, a substantial hit rate was not obtained.

By combining the Rotter Locus of Control Scale, the Accident Locus of Control Scale, and the Safety Program Influence Scale items, a discriminant analysis was capable of reducing the 88 items from these three scales down to 30 items.

This analysis showed that the 30 items were 97 to 98 percent accurate in discriminating between accident and non-accident cases. The differences in the discrimination abilities were a function of the hours of exposure. As would be expected, some subjects that had no or very few hours of work exposure during the work history time period scored in a "high accident" range but did not have the claims to show for it. By establishing minimum exposure levels, the discriminability of the items was as high as 98 percent. As exposures increased over 3000 hours for a three year time period, the discriminability between accident and non-accident cases also increased.

Multiple regression procedures were performed to identify the predictive potential of the various scales and variables upon accident severity as measured by dollar losses for claims experience. None of the total scale scores nor variables were found to be highly predictive of accident severity.

Because these variables did not predict severity when measured as a continuous variable, it was decided to categorize the claims severity into high, medium, and low loss levels. This was done by dividing the standardized losses into three equal parts of the normal distribution. The same thirty items that were capable of discriminating accident involvement were also found to be capable of predicting accident severity to a perfect level.

These results suggest that the 30 items which comprise the Three Factor Accident Prediction Inventory are not only capable of discriminating between accident and non-accident cases but also discriminating between high, medium, and low levels of accident severity.

This Three Factor Accident Prediction Inventory is comprised of items from the Accident Locus of Control Scale, the Safety Program Influence Scale, and Rotter's Internal-External Locus of Control Scale. It is believed that the externally oriented beliefs of accident causation and prevention are identified by the Accident Locus of Control Scale items. The items from Rotter's Internal-External Locus of Control Scale control for "socially desirable" answers and items from the Safety Program Influence Scale identify factors which influence not only accident involvement but also the severity of the accidents.

Six items from the Safety Program Influence Scale were found to be significant discriminators between accident and non-accident cases when combined with the locus of control scale scores. These items are:

1. Return-to-work Program
2. Accident Investigation Program
3. Safety Training on potentially hazardous equipment
4. Employee Assistance Program
5. Disciplinary Policy for Safety
6. Hazard Inspection Program with Follow-up

Each safety program component will be described in detail in the following section.

Safety Program Influences on Accidents

Studies have attempted to identify organizational and safety program characteristics that differentiate between companies with good and poor safety records.[31, 32, 33] They have found that many safety program components have been successful in reducing the accident frequency and severity rates through various approaches. Herman performed a multifaceted program at the Ford Motor Company in Mexico.[34] His program included:

1. Worker participation to detect unsafe conditions
2. Conversation on unsafe conditions
3. Job Safety Analysis
4. Safety talks with the workers

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[31]M. Smith, H. Cohen, A. Cohen, and R. Cleveland, "Characteristics of Successful Safety Programs," Professional Safety 10 (1978): 5-15.

[32]A. Cohen, A., M. Smith, and H. Cohen, "Safety Program Practices in High Versus Low Accident Rate Companies," DHEW Publication No. 75-185 (Cincinnati: National Institute for Occupational Safety and Health, 1975).

[33]H. Cohen and R. Cleveland, "Safety Program Practices in Record-holding Plants," Professional Safety 28 (1983): 26-33.

[34]J. Herman, "Effects of a Safety Program on the Accident Frequency and Severity Rates of Automobile Workers," Dissertation Abstracts 39 (1978): 5625B.

5. Weekly safety audits

6. Group recognition of workers for safe behavior

The results showed that this approach to a safety program was effective in reducing the mean severity rates and the mean frequency rates.

Because it has been theorized that the majority of accidents are due to unsafe acts, a behavioral approach to accident prevention may play an important role in accident prevention. In 1978, Komaki implemented a safety program aimed specifically at behaviors.[35] Her intervention program consisted of an explanation and a visual presentation of the desired behaviors as well as frequent enforcement in the form of feedback. This behavior approach, which was very effective in improving safety performance, showed that by behaviorally defining and positively reinforcing safe practices, one can significantly reduce the number of occupationally related accident.

Based upon findings in these studies and practices which have become common in safety management, one would expect to find strong correlations between the presence of various safety programs in the workplace and accident frequency and severity rates. These findings should be

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[35] J. Komaki, K. Barwick, and L. Scott, "A Behavioral Approach to Occupational Safety: Pinpointing and Reinforcing Safe Performance in a Food Manufacturing Plant," Journal of Applied Psychology 63 (1978): 434-444.

most obvious when comparing a location with a safety program to another without a program.

Return-to-Work Program

A Return-to-Work program is designed to reduce the severity of a workers' compensation claim once an accident has occurred. The program requires that the physical job requirements be examined and documented for all job positions in the organization. When an employee is injured, a list of the task requirements for that job function are forwarded to the physician along with a brief statement that the organization wishes to return the employee back to work with restrictions if possible. By returning the employee to work even at a limited duty, the organization will benefit in a few different ways. First, the employee will not collect total temporary disability payments. Second, they will be at work and active and lastly, the organization will not have to pay indirect losses of overtime pay for employees to work the injured employee's job.

The return to work program should affect both the severity and the frequency of accidents. An effective return to work program should cause a decrease in the frequency of injuries. This result is expected since the program communicates to employees that management will not reward chronic illness behavior.[36]

Hazard Control Program and Follow-Up

A hazard control program consists of identifying and eliminating or controlling hazards in the workplace.[37] The hazard control program should require a knowledgeable person to conduct surveys on a regular basis. Any hazards noted during the survey are documented and appropriate follow up action is taken. There are several crucial elements of hazard surveys.[38] The surveys are made to:

1. Identify potential loss situations
2. Assess the degree of loss associated with these risks
3. Select measures to eliminate or minimize losses
4. Implement recommended safety measures.
5. Monitor changes

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[36]Jonathan Gice and Kathlyn Tompkins "Cutting Costs with Return-To-Work Programs," Risk Management (April 1988): 64.

[37]National Safety Council, Accident Prevention Manual for Business and Industry. (Chicago, Illinois: NAtional Safety Council, 1992): 63.

[38]Cathie Rategan, "It's time for Your Checkup," Safety and Health 141 (1990): 42-44.

Employee Safety Training

A key element in every successful organization, in any successful accident prevention program, and in any occupational safety and health program is effective job orientation and safety training.[39] Training on the proper use of potentially hazardous equipment is one of the many areas that safety training can be directed in to reduce accidents. This training can provide the employee with an understanding of the safe and proper methods for operating and using potentially hazardous equipment.

Accident Investigation

The presence of accident investigation procedures and training were identified as an important factor that influences work related accidents and injuries. When viewed as an integral part of the total occupational safety and health program, accident investigation is especially important to determine direct causes, uncover contributing accident causes, prevent similar accidents from occurring, document facts, provide information on costs, and promote safety.[40] The accident investigation program requires the adoption of a policy and training of supervisors that may be required to conduct investigations.

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[39]National Safety Council, 365.

[40]National Safety Council, 277.

Employee Assistance Programs

Troubled employees cost American companies about $100 billion each year due to absenteeism, accidents, errors, sick leave and health insurance benefits.[41] The U.S. Chamber of Commerce says that typical drug users are 3.6 times more likely to injure themselves or another person in a workplace accident.[42] Employee assistance programs are cost-effective, humanitarian, job-based strategies to help employees identify problems and resolve them through confidential, short-term counseling, referrals for more specialized services, and follow-up services.[43]

Numerous studies [44, 45, 46] have been conducted which show the impact EAP's can have on improving employee productivity and reducing employer costs in the areas mentioned above. Studies have also been conducted which

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[41]Rhonda Cooke, "Low-Cost Help for Troubled Employees," Credit Union Management (February 1991): 50-51.

[42]National Safety Council, 175.

[43]National Safety Council, 175.

[44]Jim Castelli, "Addiction: Employer-provided Programs Pay Off," HR Magazine (April 1990): 55-58.

[45]Edward Miller, "Investing in a Drug-free Workplace," HR Magazine (May 1991): 48-51.

[46]Michael Major, "Employee Assistance Programs: An Idea Whose Time Has Come," Modern Office Technology 35 (March 1990): 76.

demonstrate the relationship between drugs, alcohol, and accidents.[47]

The existence of an employee assistance program may greatly affect an employee's potential for being involved in a work related accident, thus this item was identified as a major discriminator of accident and non-accident cases.

Disciplinary Policies and Safety

Like the above described safety programs, the presence of disciplinary policies were found to have an impact on work related accidents and injuries. Disciplinary policies are an important tool in any organization's management structure. Good discipline leads to acceptable conduct, whether it be in connection with safety or in connection with other types of endeavor.[48] Disciplinary policies for safety allow for a means of reinforcing the desired safe behaviors. The disciplinary policies should be documented and all employees should be made aware of them.

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[47] Martin Shain, "Alcohol, Drugs, and Safety: An Updated Perspective on Problems and their Management in the Workplace," Accident Analysis and Prevention 14, no. 1 (1982): 239-246.

[48] Marie Scotti, "How to Supervise a Positive Discipline Program for Safety," Professional Safety (April 1986): 25-27.

Summary

The literature reviewed for this study has shown that the locus of control construct has been useful in predicting occupational accident involvement. The Employee Safety Inventory was developed and uses the locus of control construct as one of its underlying constructs for the Safety Control Scale. This inventory has moderate predictability for accident involvement. This inventory, as well as others currently in use, fails to account for the impact that a safety program has upon predicting work related accidents.

The ability for safety programs to reduce accident frequencies and severity has been demonstrated in several studies. The main focus of the studies has been toward implementing the programs then identifying the reduction of accidents and injuries. The six safety program components found to be significant discriminators of accident and non-accident cases have also been supported by the literature and the programs are considered common practice in the safety management field. The programs are directed toward reducing the accident frequencies and the severity.

The literature review was unable to produce any existing instruments for predicting a person's potential for work related injuries which use the combined effects of the safety program and the person's locus of control. The 1992 Pilot Study yielded very positive results when measuring these combined factors. The 1992 Pilot Study not only yielded very high hit rates for discriminating between accident and non-accident cases, it was also capable of accurately discriminating between low, medium, and high severity levels for the accident cases.

This study will attempt to confirm these results using an instrument with items that measure the subjects' general locus of control, the subject's accident locus of control, and the safety program influence. The instrument's use will be valid only in those organizations with similar exposures, however, if the results are successful, the methodology used to construct this inventory may be followed to construct inventories for other work exposure settings.

CHAPTER III

PROCEDURES

The purpose of this study was to develop an inventory that is capable of predicting a person's potential for involvement in work related accidents and predict the severity of the accidents. The Three Factor Accident Prediction Inventory was developed to accomplish this goal.

The underlying construct termed "Locus of Control" was used as a basis for the items in this inventory. The term "Locus of Control" is defined as the degree to which a person places the cause of unwanted events internally, with the cause of the unwanted event being due to things that the person believes they have control, and externally, with the cause of the unwanted event being due to things that the person believes they do not have control.

Inventory Construction

The inventory consists of three scales; a General Locus of Control Scale, an Accident Locus of Control Scale, and a Safety Program Influence Scale. Items from Rotter's I-E Locus of Control Scale were identified as being significant predictors of accident and non-accident cases through the use of linear discriminant analysis. This procedure yielded 13 items which were re-written for this inventory. The new items attempted to keep the original general item content.

Thirteen items from the Accident Locus of Control Scale were identified as being significant predictors of accident and non-accident cases through the use of linear discriminant analysis. These items were original and specifically developed for the 1992 Pilot Study.

Six items from the Safety Program Influence Scale were also identified as being significant predictors of accident and non-accident cases through the use of linear discriminant analysis. The Safety Program Influence Scale was used to identify differences in the safety programs at the various locations and the influence upon the subjects' accident potential. Some of the safety program components play a role in controlling the severity of the accident while others are directed at preventing accidents from occurring. The major safety program areas are safety training, return-to-work programs, accident investigations, employee assistance programs, hazard surveys, and disciplinary policies.

Together, the three scales comprise the Three Factor Accident Prediction Inventory. The items from the General Locus of Control Scale and the Accident Locus of Control

Scale were randomly arranged into one scale which was administered to the subjects. The Safety Program Influence Scale was scored separately. All safety program data was obtained from the 1989 Park District Risk Management Agency's Loss Control Program evaluation. A copy of the Three Factor Accident Prediction Inventory is located in Appendix 1.

Technical information about the Three Factor Accident Prediction Inventory's performance was addressed following the American Psychological Association's Standards for Educational and Psychological Testing.

Instrument Scoring and Standardization

Items were scored by assigning a "0" to the external answers on the employee inventories and a "1" for the items with internal responses. A "0" was assigned to the safety program influence items that were missing at the time of the program evaluation and a "1" if the programs were present and met the specified criteria. The guidelines for scoring the Safety Program Influence items are in Appendix 2.

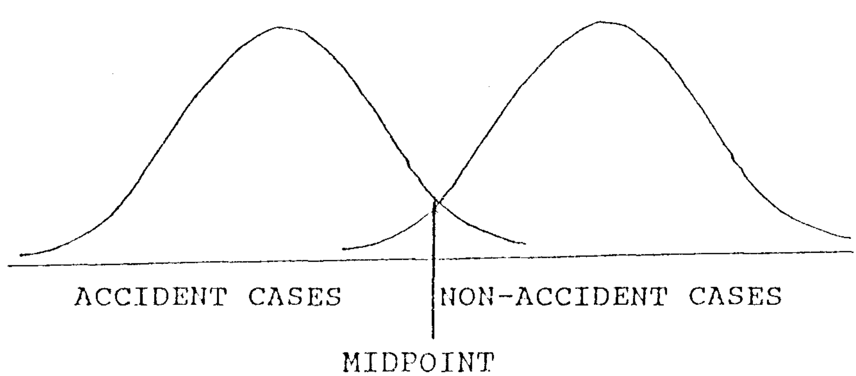
The total score for the inventory was derived by multiplying the item score with the unstandardized discriminant function. These results were then summed for each subject resulting in the unstandardized discriminant score. This score was computed for each subject using the

Statistical Package for the Social Sciences (SPSSX) Data Analysis System's Discriminant program.

Classification Table Construction

Accident and Non-accident cases. Subjects were divided into accident and non-accident groups based on the definition of "accident" stated in the Definitions section of this paper. The group means and standard deviations were calculated using the unstandardized discriminant scores. Taking the midpoint between the group means, a cutoff score was identified. A representation of this technique is presented in Table 1.

Table 1.--Cutoff Score Determination:
Accident and Non-Accident Cases

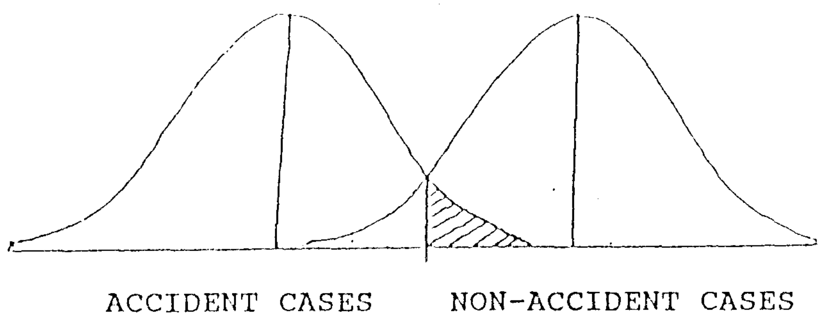


Probabilities for correct classifications were determined by calculating the probabilities of being in the tail of the incorrect group but having a score that places the subject in the identified group. Using this procedure, classification tables were constructed. An example of this technique is presented in Table 2.

A case was classified as an accident case if their discriminant score was equal to or less than the value labeled as midpoint in Table 2. The probabilities of being mis-classified was determined by calculating the proportion of the population in the accident group that scored above the cut-off score. This proportion is represented by the shaded area of the normal distribution curve.

To account for differences in work exposure levels, classification tables were developed for the population based upon ranges of hours worked during the three year accident history time period. The standard error of measurements were reported for each score.

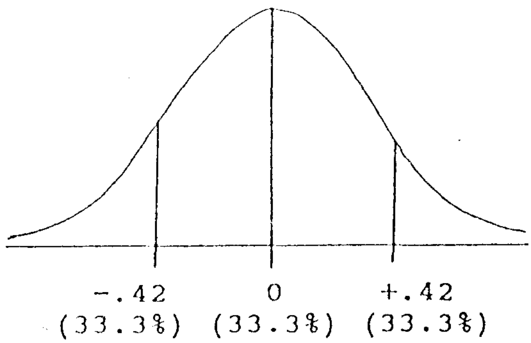
Table 2.--Procedure for Determining Classification Probabilities: Accident and Non-accident Cases.



(SHADED AREA REPRESENTS SUBJECTS IN ACCIDENT GROUP THAT WERE INCORRECTLY CLASSIFIED INTO NON-ACCIDENT GROUP)

<u>Accident severity</u>. Dollar losses sustained by the accident cases were standardized along a normal distribution. The distribution was then divided into three equal thirds and the cut-off loss scores were obtained. The accident cases were then assigned to their appropriate loss severity group of low, moderate, or high. The group means and standard deviations were calculated using the unstandardized discriminant scores. This technique is presented in Table 3.

Table 3.--Cutoff Score Determination: Accident Severity



In the accident classification procedures, probabilities for correct classifications in severity groups were determined by calculating the probabilities of being in the tail of the incorrect group but having a score that places the subject in the identified group. To determine classification accuracy for accident severity, the discriminant analysis hit rates were used. Two discriminant functions were determined for each case. The procedure grouped the cases according to their membership on a coordinate system. Using this procedure, classification tables were constructed. An example of this technique is presented in Table 4. There were not enough accident cases to break them down into groups based upon hours worked during the three year accident history time period.

Table 4.--Procedure for Determining Classification Probabilities: Accident Severity

		(Function 2)			
		+40			
HIGH SEVERITY		+20	MODERATE SEVERITY		
-40	-20	0	+20	+40	(Function 1)
LOW SEVERITY		-20			
		-40			

Sources of Data

Population Selection

Member organizations of the Park District Risk Management Agency were used as the source of data for this study. The Park District Risk Management Agency is an insurance risk pool comprised of 110 Park Districts, Special Recreation Associations, and Forest Preserve Districts in Illinois. All members were asked to submit employee rosters. The subjects for this study were randomly selected from the Park District full-time employee lists. Due to differences in the work environment exposures, special recreation associations and forest preserve districts were not included in the population.

All subjects in the population were numbered sequentially from 1 to 2672. A random numbers table was used to select the subjects. Five-hundred subjects were chosen in order to meet the number of cases per item ratio of 20 as suggested by Stevens for the linear discriminant analysis procedure.[49] This case per item ratio is recommended for performing stepwise discriminant analysis procedures. In this study, approximately 17 cases per item were obtained and all items will be entered into the analysis.

Inventory Administration and General Testing Considerations

The inventory was administered during February 1993. Copies of the Inventory, work history summary questionnaires, and cover letters were sent to the PDRMA Board representative at Districts where the subjects were employed. The Park District Board members were given two weeks to administer and return the inventories. To provide some uniformity in the inventory administration, a letter

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[49]James Stevens, Applied Multivariate Statistics for the Social Sciences (Hilldale, New Jersey: Lawrence Earlbaum Associates, Publishers, 1986): 259.

outlining the general testing considerations was sent with the inventories to each Board Representative.

Descriptive Analysis

A descriptive analysis was performed on the data. The results include the number of cases, mean scores, accident classifications, exposure levels, and standard deviations. All statistical procedures described in this section were performed using SPSSX 4.0.

Accident and Loss History Data

For the purposes of this study, an accident case was defined as any full-time employee that sustained an injury that resulted in a workers' compensation claim with the Park District Risk Management Agency during the three year time period of January 1, 1990 to December 31, 1992.

An accident history and loss data was obtained for a three year maximum period for each employee prior to the date of the testing. The data was collected from the insurance pool in January, 1993. Analyses were conducted on the data to ensure that it was accurate thus reducing the possibility of incorrectly classifying subjects as accident or non-accident cases.

The accident frequency data was measured in terms of claims filed with the insurance pool and the severity was measured in terms of dollars paid per claim. Total accident severity was measured by summing all losses sustained during the three year analysis period.

Power Analysis

The power of a test is defined as the probability of rejecting the null hypothesis when the hypothesis is false. An Alpha level .05 has been chosen for this study because this level is most commonly accepted in research studies. In a population of 500 subjects, correlations of .20 have a power level of .99 for two tailed tests with an Alpha level of .05.[50]

Inventory Validity

Content validity was examined in this study for all three scales. The locus of control items were validated by comparing the content of the items to items on already existing inventories. The content for the Safety Program Influence Scale was validated by identifying programs that have been shown to have an impact on work related accident frequencies and severity.

Criterion related validity was examined to test whether the Three Factor Accident Prediction Inventory is capable of distinguishing accident cases from non-accident cases at a significant level. The results include a complete description of the sample, the number of cases,

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[50] Stevens, 529.

all measures of central tendency, all measures of variability, and the relationships between Inventory scores and accident involvement. Correlations between accident involvement and the unstandardized discriminant scores were derived using the ETA correlation procedure.

The population was then broken down into groups based on the number of hours worked during the three year accident history period. Correlations between accident involvement and the unstandardized discriminant scores were derived using the ETA correlation procedure for these groups. The results identified the influence that work exposure has upon the Inventory's ability to correctly classify employees.

Accident cases from the population were broken down into groups based on the severity of the accidents sustained during the three year analysis period. The method for determining accident severity groups is described in the Inventory Scoring section of this chapter. The cases were assigned to their appropriate group then correlations between group membership and the unstandardized discriminant scores were derived using the ETA correlation procedure for these groups. The resulting correlations signify the validity of the Inventory on predicting accident severity group membership.

Further validation of the instrument was addressed in the Discriminant Analysis Section of this chapter.

<u>Inventory Reliability</u>

The reliability of the instrument scoring procedures and inventory performance was addressed in this study. To ensure reliability with the Safety Program Influence Scale, guidelines were established for scoring the instrument. In order to receive credit for the various safety program components, specific requirements had to be met. The procedures for assigning values to the responses are discussed in the Instrument Scoring and Standardization section of this chapter.

Reliability in scoring the locus of control items was addressed in the same manner by having pre-established internal and external responses for each item.

The internal consistency of the locus of control items on the Three Factor Accident Prediction Inventory was examined using the Spearman-Brown Split-half reliability procedure. The inventory reliability for the total population was determined as well as the number of subjects, mean scores, standard errors of measurement, and standard deviations.

The population was broken down into groups based on the number of hours worked during the three year accident history period. Spearman-Brown Split-half reliability coefficients, the numbers of valid cases, mean scores, standard deviations, and standard errors of measurement were derived for each exposure group. The results were reported in the classification tables.

Because the Safety Program Influence items were selected based on prior results of subjects in the Park District setting, the reliability of the test should not be generalized across to other work environments. Safety Program Influence items should be developed for the many different work environments.

Discriminant Analysis

A discriminant analysis was performed to derive the inventory scores, develop the classification tables, and further examine the validity of the instrument used in this study.

Accident and Non-accident Classification. The data was examined using the linear discriminant analysis to determine accident and non-accident classification accuracy using the Inventory scores. In order to meet the assumptions of the discriminant analysis procedure, the data for the high accident potential and low accident potential groups must have multivariate normal distributions. The Box-M Test for multivariate normality was performed to determine if the data met this assumption.

Hit rates were obtained for the population to determine the accuracy of the inventory in predicting membership in the accident and non-accident groups. The hit rates were calculated for the population along a continuum of exposure levels as measured by total hours worked during the three years of accident history. Hit rate tables were developed for the various exposure levels.

<u>Accident Severity Classifications</u>. The discriminant analysis procedure was also performed to develop the classification tables and further examine the validity of the test instruments in predicting accident severity levels. As was the case for accident and non-accident classification, in order to meet the assumptions of the discriminant analysis procedure, the data for the three severity groups must have multivariate normal distributions. The Box-M Test for multivariate normality was performed to determine if the data met this assumption.

Hit rates were also obtained for the accident cases to determine the accuracy of the inventory in predicting membership in the accident severity groups. The hit rates were calculated for the population along a continuum of exposure levels as measured by total hours worked during the three years of accident history. Hit rate tables were developed for the various exposure levels.

Confirmatory Factor Analysis

As a final test of validating the underlying constructs of the Three Factor Accident Prediction Inventory, a confirmatory factor analysis was performed. This procedure was used to see if the items which make up the three separate scales in the Three Factor Accident Prediction Inventory correctly measured the three underlying constructs.

Lisral was used to construct and test the model proposed in this study. The Inventory items were weighted on three factors which are a general locus of control construct, an accident locus of control construct, and the safety program influence. Table 5 indicates the three factors and the items that were loaded upon them.

The model was interpreted by testing the total coefficient of determination with the Chi-square test of significance. A non-significant Chi-square would indicate that the data fit the proposed model.

Table 5.--The Confirmatory Factor Analysis Model

Locus of Control General	Locus of Control Accident	Safety Program Influence
Item 2	Item 1	SP Item 1
Item 3	Item 4	SP Item 2
Item 6	Item 5	SP Item 3
Item 8	Item 7	SP Item 4
Item 9	Item 10	SP Item 5
Item 11	Item 12	SP Item 6
Item 13	Item 14	
Item 15	Item 16	
Item 18	Item 17	
Item 21	Item 19	
Item 23	Item 20	
Item 24	Item 22	

CHAPTER IV

RESULTS

Population Selection

Five hundred subjects were randomly selected from 2,672 full-time employees in park districts that comprise the Park District Risk Management Agency's risk insurance pool. The population was obtained from full-time employee lists received from the 110 park districts, forest preserve districts, and special recreation associations. Each employee was counted and received a case number. A random numbers table was then used to select 500 subjects.

Accident and Loss History Data

Once the subjects were identified, their accident history was obtained for the three year time period from January 1, 1990, to December 31, 1992, and their respective District's safety program information was obtained from the 1990, 1991, and 1992 Loss Control Program Evaluations.

Initial statistics showed that approximately 18 percent of the 500 potential subjects involved had at least one workers' compensation claim during the three year time period.

Response Rates and Sample Summaries

The inventories were distributed to 81 Districts in which the 500 randomly selected subjects belonged. Cover letters and instruments were sent to the Districts' PDRMA board representatives. Districts were given two weeks to administer the instruments and return them to the PDRMA offices. Follow-up telephone calls were made to those that had not sent their Inventories back by the due date.

The 1990, 1991, and 1992 safety program evaluations were reviewed for the 81 districts to obtain the scores for the Safety Program Influence scale. Four districts were found not to be members of the insurance pool for the entire three year loss history time period. Subjects from these districts were excluded from the study to ensure that all districts had equal safety program exposures. These four districts had a total of 21 cases that were removed from the study. Due to this modification, the sample population was reduced to 479 potential subjects and 77 districts.

Of the 468 cases, 305 were received for a response rate of 66 percent. These cases represented 65 Districts out of 81 (80 percent). More instruments were received after the due date and will be analyzed in a follow up study.

The claim history for the obtained population was analyzed to identify the accident involvement and claim severity. The descriptive summary is presented in Table 6.

Of the 305 cases received, there were 211 valid cases that were used in the analysis. Cases were determined to be invalid because of improper completion of the instruments. One reason for the low valid case number is due to the fact that many subjects either circled two choices in the same item, did not answer all of the items, or chose not to participate.

Table 6.--Obtained Sample:
Summary of Claim Involvement

	N	Percent
Accidents Cases	35	16.6
Non-accident Cases	176	83.4
Total	211	100.0

All claims information was obtained from the insurance pool for the three year loss time period of January 1, 1990, to December 31, 1992. Thirty-five participants were involved in at least one workers' compensation claim during the three year loss history time period with the losses ranging from no dollar losses to $27,000. A descriptive summary of the claims data is presented in Table 7.

Table 7.--Claims: Descriptive Summary

	N	Mean	SD	Minimum Loss	Maximum Loss
Claims	35	$2,052.63	$5,125.13	0	$27,800

When developing the standardized loss scores, the $27,000 loss was determined to be an outlier due to the fact that it was not possible to standardize the losses into three categories based upon their relationship to the normal distribution. By removing this loss from the sample, the losses became more evenly distributed. The claims summary used to complete the study is displayed in Table 8.

Table 8.--Claims: Descriptive Summary with Outlier Removed

	N	Mean	SD	Minimum Loss	Maximum Loss
Claims	34	$1,295.35	$2,526.53	0	$11,200

An employee's potential for being involved in an accident can be affected by their exposure to the job. The most common measure of this exposure is the number of hours worked during a specified time period. Employees that work more hours in a given time period may be expected to have a greater potential for being involved in an accident. In this study, the work exposure was determined by calculating the hours worked by each subject during the three year loss history period. Each subject was asked to complete a work history summary. The results of the population work history is presented in Table 9. Subjects for the random sampling were taken from full-time employee lists, therefore as would be expected, many subjects fell into the 6000 hour category. This was calculated by multiplying three years of full-time work by 2,000 hours per year.

Table 9.--Summary of Work Exposure

	N	Percent
1 - 2,999 Hours	28	13.3
3,000-5,999 Hours	36	17.1
6,000 and Over	147	69.7
Total	211	100.0

Inventory Scoring

The linear discriminant analysis procedure was used to derive the item weightings which in turn were used to calculate the inventory scores and classification tables. The discriminant procedures were performed using SPSSX. All items were entered into the equation using the direct method. This technique yielded unstandardized linear discriminant weights. By multiplying the subject's response by this weight and then summing all items, total unstandardized discriminant scores were obtained. These scores were used to classify the subjects into accident and non-accident categories. The unstandardized linear discriminant weights are presented in Table 10 for accident and non-accident classifications.

Table 10.--Unstandardized Linear Discriminant Weights by Item for Accident and Non-accident Classifications

Item	Weight	Item	Weight
1	.040	16	.218
2	-.090	17	-.231
3	-.311	18	.267
4	-.534	19	-1.00
5	.852	20	-.672
6	-.638	21	-.670
7	-.540	22	1.18
8	-.951	23	.664
9	-.002	24	-.260
10	.818	25	.081
11	-.556	26	-.616
12	4.53	27	.353
13	.348	28	.269
14	-.009	29	.578
15	2.33	30	.309
		Constant	-3.02

The linear discriminant analysis procedure was used to derive the unstandardized linear discriminant scores for the severity classification scores. When classifying the subjects into severity groups, there were three potential groups of low, moderate, and high severity. By multiplying the subject's response by this weight and then summing all items, the total unstandardized discriminant scores were obtained. Two unstandardized linear discriminant functions were obtained for each subject and plotted on a coordinate plane. These plotted scores were used to classify the subjects into low, moderate, and high accident severity categories and identify the respective areas on the coordinate plane. The obtained unstandardized linear discriminant functions and the classification areas are presented in Table 11.

Table 11.--Unstandardized Linear Discriminant Weights by Item for Accident Severity Groups

Item	Score 1 Weight	Score 2 Weight	Item	Score 1 Weight	Score 2 Weight
1	8.479	-2.316	16	13.176	-1.065
2	3.679	5.207	17	-10.768	1.580
3	14.838	-2.867	18	18.287	-1.252
4	12.356	2.228	19	-23.868	1.105
5	20.920	6.797	20	-2.242	1.924
6	71.448	1.796	21	-16.052	1.434
7	-25.742	-.159	22	-26.352	-4.639
8	17.838	-7.940	23	7.860	.299
9	-19.769	1.431	24	24.884	5.650
10	-9.103	-1.505	25	-18.996	.752
11	-14.431	.038	26	-10.628	-.055
12	16.274	5.115	27	13.615	-.151
13	30.417	-2.214	28	6.417	.329
14	4.617	3.747	29	.886	-1.270
15	12.329	-2.598	30	-12.036	-.775
			Constant	-88.516	-11.444

Inventory Score Descriptive Statistics

Accident Involvement

A descriptive analysis on the obtained accident and non-accident classification inventory scores was performed. In Table 12, the Inventory Scores are summarized by accident involvement. The mean discriminant score for accident cases was -1.20 and .24 for non-accident cases.

Table 12.--Descriptive Summary of Inventory Scores by Accident Involvement

	N	Mean	SD	Minimum Score	Maximum Score
Accidents Cases	35	-1.20	1.50	-6.42	1.20
Non-accident Cases	176	.24	.87	-1.71	2.52
Total	211	.00	1.13	-6.42	2.52

Analysis on variance procedures were performed to determine if significant differences exist between the mean inventory scores for accident and non-accident cases. As would be expected from the discriminant procedure used to score the cases, a significant difference did exist between mean accident case scores and non-accident case scores ($P < .000$).

Work Exposure

The Inventory scores were analyzed according to work exposure levels. Exposure groups were established by dividing the maximum exposure hours, which is 6,000 hours in the three year loss history period, into three categories. The results of this analysis are displayed in Table 13.

Table 13.--Descriptive Summary of Inventory Scores by Work Exposure

	N	Mean	SD	Minimum Score	Maximum Score
1 - 2,999 Hours	28	.36	1.01	-1.91	2.10
3,000-5,999 Hours	36	-.04	.88	-1.49	2.52
6,000 Hours and Over	147	-.06	1.20	-6.42	2.36
Total	211	.00	1.13	-6.42	2.52

Analysis on variance procedures was performed to determine if significant differences exist between the mean inventory scores for the three exposure levels. The results for this procedure are displayed in Table 14. The mean discriminant scores for the three exposure levels were not significant ($F = 1.67$, $P > .05$).

Table 14.--Analysis of Variance Results:

Mean Scores by Exposure Levels

N	SS	DF	MS	F	Sig.
211	4.28	2	2.14	1.67	.189

Accident Severity

Accident severity was measured by taking the total severity for each subject and placing the losses on a normal distribution. A subject's severity was measured by the total dollars incurred during the three year time period. The loss distribution was standardized and divided into thirds. As described in the inventory scoring section of this chapter, there were two unstandardized linear discriminant functions for each subject required to classify the losses into low, moderate, and high loss categories. The summary of the discriminant functions are displayed in Tables 15 and 16.

Table 15.--Descriptive Summary of Function 1: Inventory Scores by Severity Group

	N	Mean	SD	Minimum Score	Maximum Score
Low Severity Cases	13	-4.01	.85	-5.13	-2.27
Moderate Severity Cases	17	10.17	1.14	7.48	11.67
High Severity Cases	4	-30.20	.71	-30.85	-29.19
Total	34	.00	13.08	-30.85	11.67

The mean discriminant scores in table 15 are the X-axis values for the severity classification and the mean discriminant scores in table 16 are the Y-axis values. By plotting each exposure level on a coordinate system, it is possible to determine each accident case's severity group membership.

Table 16.--Descriptive Summary of Function 2: Inventory Scores by Severity Group

	N	Mean	SD	Minimum Score	Maximum Score
Low Severity Cases	13	-1.93	1.30	-4.25	-.01
Moderate Severity Cases	17	.96	.78	-.78	2.14
High Severity Cases	4	2.20	.62	1.69	3.02
Total	34	.00	13.08	-4.25	3.02

Inventory Validity

Accident Involvement

Criterion related validity is defined as the ability to predict accident and non-accident cases based on the total inventory scores obtained for the subjects. This was determined by performing ETA correlations using the classification groupings and the accident classification inventory scores. The results from this procedure indicate that there is a significant relationship between the obtained inventory scores and accident involvement (See Table 17).

Table 17.--Inventory Criterion Related Validity: Inventory Scores Correlated with Accident Involvement

N	Eta	Eta^2	Power*
211	.474	.225	>.99

*Alpha=.05

The validity of the inventory scores for determining accident classifications was also analyzed for the various work exposure levels. These results suggest that the inventory is most valid in predicting accident and non-accident involvement when the exposure hours are at 6,000 for a three year time period (See Table 18).

Table 18.--Inventory Criterion Related Validity: Inventory Scores Correlated with Accident Involvement Broken Down by Work Exposure Levels

	N	Eta	Eta^2	Power*
1 - 2,999 Hours	28	.365	.133	>.35
3,000-5,999 Hours	36	.264	.069	>.22
6,000 Hours and Over	147	.512	.262	>.99

*Alpha=.05

Accident Severity

The validity of the Inventory for predicting accident severity classifications was examined using the discriminant analysis procedure. As will be discussed in the Linear Discriminant Analysis section of this chapter. High classification rates were obtained for the sample using the discriminant functions to classify accident cases as low, moderate, and high in claim severity. It must be noted however, the desired number of accident cases needed for this procedure was not obtained.

The procedure was not performed over the three exposure levels because the number of cases would be even fewer for each table.

Inventory Reliability

The reliability of the inventory's performance was addressed by performing the Spearman-Brown Split-half reliability procedures on the scores. This procedure was used on the entire sample population, the population broken down by accident involvement, and the population broken down by work exposure levels. Only 24 items were included in the reliability tests because six of the thirty items dealt with safety program evaluations and required no completion by the subjects. The results of the reliability tests are presented in Tables 19, 20, and 21.

Table 19.--Inventory Reliability:
Spearman-Brown Split-half Reliability Coefficients
for the Entire Population

N	r	r^2	Power*	SD	SEM
211	.756	.571	>.99	3.63	1.79

*Alpha=.05 Number of Items=24

In Table 19, the overall reliability of the inventory appears to quite good with a high reliability coefficient that meets a high power level (r = .756, Power > .99). These results suggests that there is consistency in the manner that the subjects answered the items. When examining the items broken down by work exposure, it appears that the inventory's reliability is maintained across all levels (See Table 20). All reliability coefficients met a minimum power level of .99.

Table 20.--Inventory Reliability:
Spearman-Brown Split-half Reliability Coefficients
Broken Down by Work Exposure Levels

	N	r	r^2	Power*	SD	SEM
2,999 Hours and Less	28	.903	.815	>.99	4.48	1.40
3,000-5,999 Hours	36	.801	.641	>.99	3.31	1.48
6,000 Hours and Over	147	.712	.508	>.99	3.55	1.90

*Alpha=.05 Number of Items=24

There was a difference in the reliability coefficients obtained when examining subjects by accident involvement. The larger non-accident proportion maintained the high reliability with an equally high power level.

The non-accident cases did perform as well. Their reliability coefficient of .560 only met a power level of approximately .88. A correlation of .60 or greater was needed to obtain the power level of .98.

Table 21.--Inventory Reliability:
Spearman-Brown Split-half Reliability
Coefficients Broken Down by Accident Involvement

	N	r	r^2	Power*	SD	SEM
Accidents Cases	176	.784	.615	>.99	3.76	1.75
Non-accident Cases	35	.560	.314	>.88	2.94	1.95

*Alpha=.05 Number of Items=24

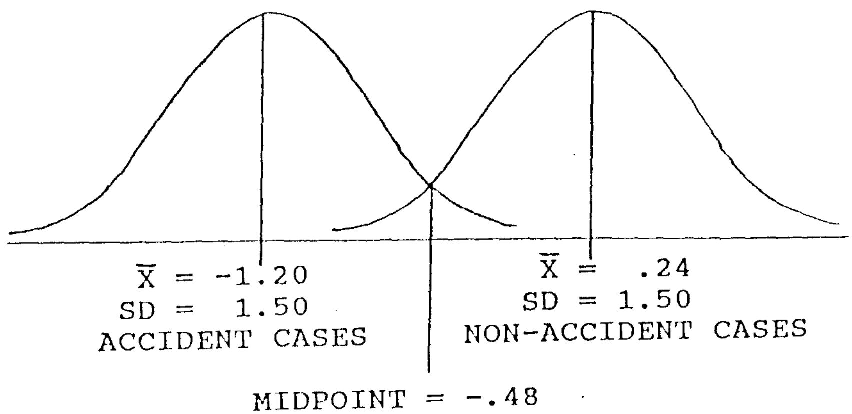
Classification Tables Development

Accident/Non-accident Groups

Classification Tables were developed for the populations. These Tables were developed using the following methods. First, the unstandardized linear discriminant scores were calculated for all cases and the population was broken down into the two groups of accident and non-accident cases. Next, the unstandardized linear discriminant scores were standardized for each subject in their respective groups.

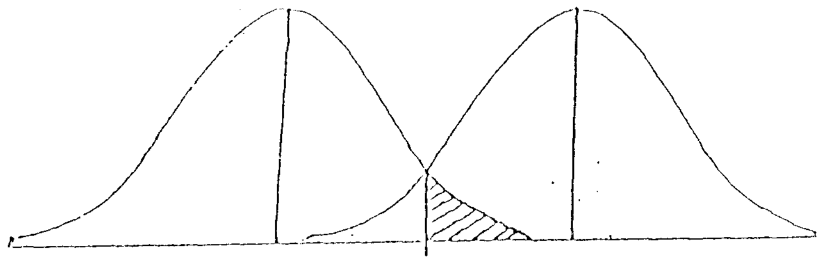
Accident group cutoff score determination. The two distributions were placed on the same distribution, and the mid-point between the two means was obtained. This midpoint is the cutoff score for classifying the subject as accident or non-accident. A graphic representation of this procedure in presented in Table 22.

Table 22.--Cut-off Score Determination



<u>Accident group classification probability determination</u>. Because the scores for the two groups are assumed to be normally distributed, it was possible to determine the probability of being mis-classified by determining the proportion of the "incorrect group's" distribution that overlaps the obtained score. An example of this technique is presented in Table 23. This process was followed for determining accident/non-accident classifications for the subjects using ranges of Inventory scores.

Table 23.--Accident Group Classification Probability Determination: Total Population



ACCIDENT CASES NON-ACCIDENT CASES

(SHADED AREA REPRESENTS SUBJECTS IN ACCIDENT GROUP THAT WERE INCORRECTLY CLASSIFIED INTO NON-ACCIDENT GROUP)

The Z-scores were used to determine the proportion of subjects that could score the obtained score but actually be in the "other" category. For example, a subject could obtain a score of -.29 and thus be classified as a non-accident case because the obtained score is above the mid-point cut-off score. However, because the two distributions overlap in this region, the subject could be in the upper region of the accident case distribution with the same obtained score. The probability of being in this end of the accident distribution was calculated and reported for each score region. This technique was used to develop the classification tables presented in Table 24.

Table 24.--Accident Group Classification Table:

Total Population

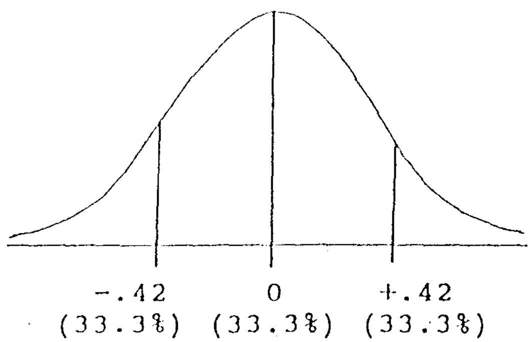
Obtained Score Range	Predicted Group	Probability of Being in "other" group
> +2.33	Non-accident	< .8%
2.32	Non-accident	.9%
2.12	Non-accident	1.4%
1.92	Non-accident	1.9%
1.72	Non-accident	2.6%
1.52	Non-accident	3.5%
1.32	Non-accident	4.6%
1.12	Non-accident	6.1%
.92	Non-accident	7.9%
.72	Non-accident	10.0%
.52	Non-accident	12.5%
.32	Non-accident	15.7%
.12	Non-accident	18.9%
-.08	Non-accident	22.7%
-.28	Non-accident	27.1%
-.48	Accident	22.4%
-.68	Accident	16.1%
-.88	Accident	11.1%
-1.08	Accident	7.4%
-1.28	Accident	4.6%
-1.48	Accident	2.8%
-1.68	Accident	1.6%
-1.88	Accident	.9%
> -1.89	Accident	<.8%

Accident Severity Groups

A table was developed to classify accident cases into low, moderate, and high severity groups. The linear discriminant analysis procedure was used to calculate the unstandardized linear discriminant weights for two functions that are required to classify a population into three potential groups. The following sections describe the statistical procedures used to establish this classification table.

Severity group cutoff score determination. The loss distribution as measured in dollars was standardized and fitted to a normal distribution curve. The area of the normal distribution was then split into equal thirds and the standardized loss levels at each point was identified. These points became the cutoff scores for classifying the accident cases as low, medium and high severity levels. A graphic representation of this procedure in presented in Table 25.

Table 25.--Severity Group Cut-off Score Determination



Severity group classification determination. For each accident case, two unstandardized linear discriminant functions were obtained. The functions were graphed onto a coordinate system and the cases plotted. The high, moderate, and low severity groups were clustered in three distinct areas of the coordinate system. An example of this technique is presented in Table 26.

Table 26.--Severity Group Classification Determination

```
                 (Function 2)
                     +40|
HIGH                    |    MODERATE
SEVERITY             +20|    SEVERITY
------------------------|------------------
-40       -20          0|  +20      +40   (Function 1)
                        |
LOW                  -20|
SEVERITY                |
                     -40|
```

<u>Severity group classification tables</u>. Using the table above, it is possible to determine the function scores, plot the cases, and describe the accident cases as low, medium, and high in potential severity. All inventories that identify a subject as an accident case from the accident and non-accident inventory procedure are scored a second time for a severity classification. The response for each item is multiplied by the unstandardized linear discriminant function and summed for the two severity classification functions. The case is plotted on the classification table and depending upon where it falls on the table, a severity classification is assigned.

Linear Discriminant Analysis

A linear discriminant analysis was performed to test the ability of the Three Factor Accident Prediction Inventory to correctly classify cases based upon accident involvement and accident severity.

Box's M test of multivariate significance was performed to determine if the covariance matrices are homogeneous and thus meet the assumptions of linear discriminant analysis procedure. The results are presented with each table. Due to the small sample obtained for some of the tables it was not possible to perform this procedure and test this hypothesis.

Hit Rates for Accident/Non-accident Groups

Using the discriminant score for the subjects, hit rates were calculated for the subjects to identify the accuracy of the Inventory in predicting accident and non-accident group membership. The hit rates were calculated for the entire population as well as sub-groups based on work exposure levels. The results are displayed in Tables 27, 28, 29, 30 and 31.

When analyzing the hit rates for predicting accident involvement, a hit rate of 77.3% was obtained for the entire population (Table 27). By breaking the population down into three exposure levels, it is possible to see the inventory's difficulty in classifying the case with fewer than 6,000 hours.

Table 27.--Hit Rates: Entire Population

Actual Group Membership	Number of Cases	Predicted Group Membership Non-Accident	Accident
Non-accident	176	138 (78.4%)	38 (21.6%)
Accident	35	10 (28.6%)	25 (71.4%)

Total of "Grouped" cases correctly classified: 77.3%

Box's M = 1085.6 F=1.5214 Significance P=.000

To determine the hit rates for the exposure classification groups of 1 to 2,999 hours and 3,000 to 5,999 hours, the discriminant weights obtained from the 6,000 hour and over group were used. Fisher's linear discriminant functions were identified for the accident and non-accident groups in the 6,000 and over group. An algorithm was written to determine the group classifications based upon these functions and cross tabulations were calculated to determine actual and predicted group classifications. By performing this procedure, it was possible to see the effect that exposure hours have on correct classifications. For the lower exposure groups, the majority of incorrectly classified cases were non-accident cases that were classified as accident cases. This suggests that these cases may be accidents yet to occur. The results are presented in Tables 28 and 29.

Table 28.--Hit Rates: Work Exposure: 2,999 Hours and Under Using Weights from the 6,000 Hour and Over Group

Actual Group Membership	Number of Cases	Predicted Group Membership Non-accident	Accident
Non-accident	25	17 (68%)	8 (32.0%)
Accident	3	2 (66.6%)	1 (33.3%)

Total of "Grouped" cases correctly classified: 64.3%

Box's M: Not enough cases were obtained.

In Table 28, eight of the 28 cases (28.6%) were mis-classified as accident cases while 2 of the 28 cases (7.1%) were mis-classified as non-accident cases. These results suggest that, at the time of the study, the mis-classified accident cases may not have had enough work exposure to be involved in an accident. If given more time, the continued lack of safety programs, and an external locus of control, the subjects may eventually be involved in an accident.

Table 29.--Hit Rates: Work Exposure: 3,000 - 5,999 Hours Using Weights from the 6,000 Hour and Over Group

Actual Group Membership	Number of Cases	Predicted Group Membership Non-accident	Accident
Non-accident	34	15 (44.1%)	19 (55.9%)
Accident	2	1 (50.0%)	1 (50.0%)

Total of "Grouped" cases correctly classified: 44.4%

Box's M: Not enough cases were obtained.

In Table 29, 19 of the 36 cases (52.8%) were mis-classified as accident cases while 1 of the 36 cases (2.8%) were mis-classified as non-accident cases. These results suggest that, as described above, the mis-classified accident cases may not have had enough work exposure to be involved in an accident. If given more time, the continued lack of safety programs, and an external locus of control, the subjects may eventually be involved in an accident.

Table 30.--Hit Rates: Work Exposure: 6,000 Hours and Over

Actual Group Membership	Number of Cases	Predicted Group Membership Non-accident	Accident
Non-accident	117	96 (82.1%)	21 (17.9%)
Accident	30	9 (30.0%)	21 (70.0%)

Total of "Grouped" cases correctly classified: 79.6%

Box's M: Not enough cases were obtained.

These results suggest that some subjects, with fewer than 6,000 work hours during the three year time period, did not score very well on the instrument and did not have the accident history as would be expected. The inventory may be classifying the subjects properly and it may be a matter of time before they are involved in an accident. For those subjects that worked 6,000 hours during the loss history period, the inventory was capable of classifying almost 80 percent (79.6 percent) of the subjects correctly (See Table 30).

Hit Rates for Accident Severity Groups

A linear discriminant analysis was performed to test the predictive validity of the Three Factor Accident Prediction Inventory in predicting accident severity. As was the case in some of the accident involvement classification tables, there were not enough cases to perform Box's M test.

Using the discriminant score for the subjects, hit rates were calculated for the subjects to identify the accuracy of the Inventory in predicting accident severity as measured in low, moderate, and high severity. The hit rates were calculated for the entire accident case population. The results are displayed in Tables 31.

Table 31.--Severity Group Hit Rates: Entire Population

Actual Group Membership	Number of Cases	Predicted Group Membership Low	Medium	High
Low Severity	13	13 (100%)	0	0
Medium Severity	17	0	17 (100%)	0
High Severity	4	0	0	4 (100%)

Total of "Grouped" cases correctly classified: 100%

Box's M: Not enough cases were obtained.

The inventory was capable of correctly classifying all of the accident cases based upon severity groupings. In order to generalize these results to other populations, more accident cases should be obtained in order to ensure that the results are stable and that all of the assumptions of the linear discriminant procedure are met.

Confirmatory Factor Analysis

A confirmatory factor analysis was performed to determine if the inventory items are indeed measuring three distinct constructs. Lisrel was used to perform this analysis. A correlation matrix of the thirty inventory items was converted into a covariance matrix for the analysis.

The inventory items were loaded onto three variables as was outlined in the Procedures section of this study. It was believed that 12 items loaded on a "general locus of control" construct, 12 loaded on a "safety locus of control" construct, and 6 loaded on a "safety program influence" construct. The confirmatory factor analysis identified the correlation matrix as not being "positive definite". These results suggest that there is auto-correlation among the thirty items. This further suggests that many of the items are measuring the same construct and the data does not fit the proposed model, therefore, no further analysis was possible with the established model.

CHAPTER V

DISCUSSION

The Three Factor Accident Prediction Inventory was developed to be a concise tool for predicting work related accident involvement and severity. This inventory attempts to measure the combined effects of the subject's locus of control and the influence of the safety program.

The Locus of Control Construct

The locus of control construct has been identified in previous research as a psychological trait that may predispose workers to increased accident involvement. The Locus of Control construct was first measured by Julian Rotter in 1966 as a potential predictor for clinical depression. Since that time, this construct has been examined in many fields as an underlying cause for different life events. The safety field realizes that this construct may play an important role in accident causation theories.

Research has been performed using the locus of control construct as a potential predictor for both work related and automobile accidents. This research has concluded that workers with an external locus of control were more likely to be involved in accidents than workers with an internally based locus of control. The externals believed that events in their lives were due mostly to luck, chance, and uncontrollable forces. Internals, on the other hand, believed that events in their lives were due to ability, their own actions, and influences that they could control.

Predictive Inventories

Since Rotter's work in 1966, attempts have been made to develop inventories that are capable of measuring a person's locus of control and subsequently relate the degree of control to life events including accident involvement. The Employee Safety Inventory, developed by London House Publishers in 1983, is one of the most noted inventories that uses the locus of control construct as a measure for potential accident involvement. Validity studies with this inventory show that low-risk employees had significantly higher safety control scores than the high-risk employees. Significant relationships were also found when comparing the scale scores with accident involvement.

Accidents in the work setting, however, are due to a complex interaction between the employee and the environment. The Employee Safety Inventory and other accident prediction scales have only examined the employee factors and neglected to include the environmental factors.

The Three Factor Accident Prediction Inventory

A pilot study was performed from January to July, 1992, which identified a combination of locus of control items and safety program influence items that were extremely effective in discriminating between accident and non-accident cases as well as accident severity. This pilot study identified six major safety program components and twenty-four locus of control items. The safety program components were: 1) a disciplinary policy, which covers safety infractions; 2) accident investigation procedures; 3) a return-to-work policy; 4) an employee assistance program; 5) procedures for conducting hazard surveys; 6) employee training on the use of power equipment. The resulting 30 items comprise the Three Factor Accident Prediction Inventory. The three hypothesized factors are a general locus of control construct, an accident locus of control construct, and the safety program influence.

Scoring the inventory required assigning a "1" for each item which the subject selected the internal response and assigning a "1" for each safety program component that was present during each year of the three year loss history analysis period. The linear discriminant analysis procedure was used to develop weightings for the items which would maximize the difference between the group scores.

Accident potential scores are the obtained discriminant scores for each subject. These scores are calculated by multiplying the response value by the unstandardized linear discriminant function value and then summing all values.

A second set of discriminant weights was developed for the accident cases. Two functions were obtained through the linear discriminant analysis and used to classify the cases into one of three accident severity groups.

The purpose of this study was to further develop the inventory by establishing validity and reliability values, confirm the inventory's ability to successfully discriminate between accident and non-accident cases, and confirm the inventory's ability to discriminate between low, moderate, and high severity cases as measured by the total dollar losses incurred.

Descriptive Findings

The study was conducted with the Park District Risk Management Agency (PDRMA) and its 110 members. Five hundred subjects were randomly selected from 2,672 full-time park district employees located in Illinois. The inventories were mailed to the individual district PDRMA board representatives. They were asked to administer the inventory and return it to the PDRMA offices.

Accident and safety program data were collected for the participating districts by the author of the study. Losses and safety program data was collected from January 1, 1990 to December 31, 1992. Four districts were found to have fewer than three years of membership in PDRMA and thus did not have adequate loss and safety program information. They were not included in the analysis.

A response rate of 66 percent was attained for the study by the date that the data was analyzed (305 out of 479 potential cases).

Because the inventory was administered by untrained individuals at each site and participation was done on a voluntary basis, a high percentage of subjects either did not complete the inventory or did not complete the inventory properly. Of the total cases received, only 211 cases were considered valid (44%). As will be discussed in the Recommendations for Further Study section, the inventory should be administered at one sitting with specific administration procedures.

Descriptive Summary

A descriptive analysis indicated that approximately 17 percent of all cases were involved in a work related accident as measured by worker compensation claims experience. The claims ranged from no dollars lost to $27,800 dollars. In order to standardize the losses into low, moderate, and high severity groups, the $27,000 loss was removed from the analysis. This was done because with the loss included, it was not possible to break the losses down into the three loss categories. This loss appeared to lie a great distance outside of the loss distribution. A larger number of accident cases may prevent this from occurring in future studies.

The descriptive analysis included breaking the cases down by the number of hours worked during the three year accident history time period of January 1990 to December 1992. As was expected, the majority of the cases worked 6,000 hours or more (69.7%). These work exposure levels played an important role in identifying differences in the instrument's validity and reliability.

Accident cases were found to have a mean score of -1.20 compared to a mean score of .24 for the non-accident cases. The mean scores across work exposure levels ranged from .36 for those working 1 to 2,999 hours to -.06 for those employees working 6,000 hours or more.

Linear discriminant analyses were performed to obtain the item weightings for scoring the inventory and ultimately classifying subjects into accident involvement groups and severity groups.

The accident cases obtained a mean accident classification score of -1.20 while the non-accident cases obtained a mean accident classification score of .24. The midpoint between these means was used as the cut-off score for classifying the cases. The mean scores are significantly different due to the fact that the discriminant analysis procedure's goal is to maximize the difference between the groups' mean scores.

The mean accident classification scores were not significantly different across the three work exposure groups ($P > .05$). This suggests that the instrument is not biased based on exposure levels.

Two functions were obtained for the severity group discriminant analysis. Function 1 yielded mean scores of 4.01 for low severity cases, 10.17 for moderate severity cases, and to -30.20 for high severity accident cases. Function 2 yielded mean scores of -1.93 for low severity cases, .96 for moderate severity cases, and 2.20 for high severity cases. As was the case for the accident and non-accident classification scores, the mean scores were also calculated using discriminant analysis weightings to maximize the group differences.

Inventory Validity

Inventory validity was examined for both accident involvement and accident severity. ETA correlation coefficients for accident involvement scores for the entire population were found to be significant (ETA=.474, Power >.99). These findings suggest that, for the population as a whole, a significant relationship exists between the Three Factor Analysis Prediction Inventory accident classification scores and the subjects' accident involvement.

There were significant differences between the inventory validity coefficients when examining the population broken down by the three work exposure levels of 1 to 2,999 hours, 3,000 to 5,999 hours, and 6,000 hours and greater. As may be expected, the validity coefficient was significant for the 6,000 hours and greater group (ETA=.512, Power >.99) and non-significant for the 1 to 2,999 hours and 3,000 to 5,999 hours groups (ETA=.365, Power >.35, ETA=.264, Power >.22). These findings suggest that the relationships between the inventory scores and accident involvement are not as great. It appears that many subjects with fewer hours of exposure scored at levels that would classify them as an accident case; however, they were not involved in an accident at the time of the study. It may only be a matter of time and sufficient exposure that the employee will be involved in an accident.

The validity of the Inventory in predicting accident severity was examined using linear discriminant analysis with the direct method of analyzing all items simultaneously. The hit rates for classifying the cases was perfect across all three severity groupings. One should be cautious in using these results since there were only 34 cases used in the procedure and 30 items in the inventory. This case-to-item ratio indicates that the results may be unstable.

Inventory Reliability

The Inventory reliability was analyzed using Spearman-Brown Split-half reliability coefficients. A coefficient of .756 (Power > .99) was obtained for the accident involvement scores for the entire population. This same level of reliability was obtained for the cases when examining the Inventory reliability across the various exposure levels. The accident involvement score reliability dropped to .560 with Power > .88 for accident cases. This may due to the fact that there were only 35 accident cases in the reliability analysis. A correlation of .600 would have obtained the .99 Power level. Further analysis with more cases may provide the desired power levels for this reliability coefficient.

Classification Tables

Classification tables were developed for the Three Factor Accident Prediction Inventory. The tables for classifying subjects as accident and non-accident cases were derived by identifying the midpoint between the two group means. This point was identified as the cut-off score. The probability of a case in the "other" group was determined by taking the score being scaled and determining the probability of the "other group" population lying at that score. A table was then developed for the range of possible Inventory scores (Table 24).

Subjects receiving an accident classification score of -.28 have the greatest potential for being mis-classified. Subjects with this score would be classified as a non-accident case with a 27.1 percent probability of actually being an accident case. This is the worst case scenario with the remaining classifications decreasing in potential mis-classifications from 22.7 percent down to less than .8 percent.

For future use of the instrument, it is possible to shift the selected cutoff scores for inclusion or exclusion in intervention programs to obtain a probability level that is acceptable to the Inventory user.

The severity group classification table construction consisted of first constructing a coordinate system for the two linear discriminant functions obtained in the discriminant analysis. Function 1 was plotted along the "X" axis and Function 2 along the "Y" axis. This resulted in identifying classifications based upon the quadrants into which the cases fell. The results and the locations of the severity groups in these quadrants was presented in Table 26. In order to classify future cases based upon severity scores, the case would be plotted on the coordinate system and depending upon the quadrant they fell into, a classification of low, moderate, or high severity would be assigned. Using this procedure, a classification of 100 percent was obtained, however, more accident cases should be obtained to meet the assumptions of the linear discriminant analysis procedure.

Linear Discriminant Analysis

Hit rate tables were constructed using the linear discriminant analysis procedure. Resulted from these tables were used to confirm the inventory's validity in classifying subjects into accident involvement groups and severity groups. One of the assumptions of the linear discriminant analysis procedure is that the covariance matrices are homogeneous. Box's M test is used to test this hypothesis. In this study, there were not enough valid cases in many of the tables to perform the test, therefore, caution must be exercised when generalizing these results to other populations.

The inventory was capable of correctly classifying 77.3 percent of all cases based upon accident involvement. The hit rate was improved to 79.6 percent when examining those subjects that worked 6,000 hours or more. The improvement appeared to be due to fewer non-accident cases being mis-classified as accident cases. This relates back to the influence that work exposure has upon accident involvement. Many subjects in the total population analysis received scores that classified them as accident cases but did not have the accident experience to show for the score. The tables for the other two work exposure groups did not have enough cases to be valid.

The severity classification hit rate table yielded 100 percent accuracy in discriminating cases into low, moderate, and high severity groups. More cases must be obtained before one can conclude these results to be stable.

Confirmatory Factor Analysis

The final analysis performed in this study was a confirmatory factor analysis. A model was generated by the author which placed each of the thirty inventory items into one of three factors. These hypothesized factors were a general locus of control construct, an accident locus of control construct, and a safety program influence measure. Lisrel was used to test whether the population's covariance matrix adequately met this proposed model. The matrix was determined to not be "positive definite" thus results from the procedure unobtainable. These findings suggest that there is auto-correlation among the inventory items and that all of the items are measuring one global construct.

Conclusions

The Three Factor Accident Prediction Inventory has been shown to be a valid and reliable inventory for predicting work related accident involvement in park districts over a three year period. This conclusion is based upon the correlations obtained in the Spearman-Brown Split-half reliability analyses and the ETA correlations between inventory scores and accident involvement. This inventory is believed to be the first to combine the influences of the subject's locus of control with the influence of six major safety program components.

In retrospect, adequate results may have been obtained in the discriminant analyses and confirmatory factor analysis if more cases were obtained when the data analysis was conducted. Since participation was voluntary and the instruments were administered by representatives at each location, a significant number of cases were either missing or had to be excluded from the analysis because items were not answered properly. The optimal method for obtaining the data sample would have been to have one person administer the inventory to all subjects at one sitting and confirm that all of the items were answered correctly when the instruments were turned in.

By making participation mandatory, any potential adverse selection due to certain groups choosing not to participate in the study would not influence the results.

When identifying the safety program influence items, more items should have been included in the final prediction inventory. The six items used in the inventory were selected based upon their ability to discriminate in the pilot study conducted by the author. It appears that more cases should have been used in the pilot study to ensure that the discriminant analysis results were as stable as possible.

Overall, the research methodology used in study has shown promising results for developing accident prediction inventories. Further analysis and follow up will be conducted to refine the Three Factor Accident Prediction Inventory into an even more valid and reliable instrument. The locus of control portion of the instrument may be used in any type of work situation and safety program influence scales can be developed for virtually any type of work setting to establish accident prediction inventories for a wide variety of industries and occupations.

Recommendations for Further Study

This study is only the beginning of much more research to be conducted in developing valid and reliable accident prediction tools that combine the locus of control construct with the safety program influences. The following recommendations are made to improve the Three Factor Accident Prediction Inventory:

1. Further research must be conducted to establish stable classification tables for accident severities. A larger number of subjects must be analyzed to achieve this goal.

2. An administrator's guide and pre-established testing procedures must be followed to ensure that the inventories are completed correctly.

3. Participation in the study could be made mandatory to ensure that there is no adverse selection of subjects due to specific accident groups or locations choosing not to participate.

4. A social desirability scale could be incorporated into the instrument to ensure that subjects are answering the items honestly and not in a manner they feel is the right way to respond.

5. The Safety Program Influence scale should be expanded to improve discriminability of

subjects. A larger number of items may result in more stable results across populations.

6. Historical studies should be performed to determine if the incorrectly accident cases in the low exposure groups are eventually involved in accidents.

7. Historical studies should be performed to determine if safety program involvement is shaping the subjects' beliefs about unwanted events toward an internal loci of control.

REFERENCES

Abramson, L., M. Seligman, and J. Teasdale. 1978. Learned Helplessness in Humans. Journal of Abnormal Psychology 87: 49-74.

Boye, M. W., D. S. Joy, K. B. Slora, and J. W. Jones. 1990. The Relation of the Employee Safety Inventory to Driving Accidents and Related Costs at a National Trucking Company. ESI Research Abstract No. 13. Park Ridge, IL: London House Publishers.

Boye, M. W., K. B. Slora, and J. W. Jones. 1989. Reliability of the Employee Safety Inventory. ESI Research Abstract No. 7. Park Ridge, IL: London House Publishers.

Castelli, J. 1990. Addiction: Employer-provided Programs Pay Off. HR Magazine May: 48-51.

Cohen, A., M. J. Smith, and H. H. Cohen. 1975. Safety Program Practices in High Versus Low Accident Rate Companies. DHEW Publication No. 75-185. Cincinnati: National Institute for Occupational Safety and Health.

Cohen, H. H. and R. J. Cleveland. 1983. Safety Program Practices in Record-holding Plants. Professional Safety 28: 26-33.

Connolly, S. G. 1980. Changing Expectancies: A Counseling Model Based on Locus of Control. Personnel and Guidance Journal 59: 176-180.

Cooke, R. 1991. Low-Cost Help for Troubled Employees. Credit Union Management: 50-51.

Foreman, E. I., H. D. Ellis, and D. Beavan. 1983. Mea Culpa? A study of the Relationship Among Personality Traits, Life Events, and Ascribed Accident Causation. British Journal of Clinical Psychology 22: 223-224.

Feggetter, A. J. 1982. A Method for Investigating Human Factor Aspects in Aircraft Accidents and Incidents. Ergonomics 25: 1065-1075.

Gice, J. and K. Tompkins 1988. Cutting Costs with Return-to-Work Programs. Risk Management April: 64.

Guastello, S. J. and D. D. Guastello. 1986. The Relation Between the Locus of Control Construct and Involvement in Traffic Accidents. Journal of Psychology 120: 293-297.

Hammer, R. W. 1972. Handbook of System and Product Safety. Englewood Cliffs, NJ: Prentice Hall, Incorporated.

Heider, F. 1958. The Psychology of Interpersonal Relations. New York: Wiley & Sons.

Heinrich, H. W. 1931. Industrial Accident Prevention. New York: McGraw Hill.

Herman, J. A. 1978. Effects of a Safety Program on the Accident Frequency and Severity Rates of Automobile Workers. Dissertation Abstracts 39: 5625B.

Jones, J. W. 1983. The Safety Locus of Control Scale. St.Paul, MN: The Saint Paul Companies.

Jones, J. W. and K. B. Slora. 1988. Predictive Validation Study of the Safety Control Scale. ESI Research Abstract No. 1. Park Ridge, IL: London House Publishers.

Jones, J. W. and L. J. Wuebker. 1985. Development and Validation of the Safety Locus of Control Scale. Perceptual and Motor Skills 61: 151-161.

Kelley, H. H. 1967. Attribution Theory in Social Psychology. Nebraska Symposium on Motivation. Lincoln, NE: University of Nebraska Press: 192-241.

Komaki, J., K. D. Barwick, and L. R. Scott. 1978. A Behavioral Approach to Occupational Safety: Pinpointing and Reinforcing Safe Performance in a Food Manufacturing Plant. Journal of Applied Psychology 63: 434-444.

Lefcourt, H. M. 1981. Research with the Locus of Control Concept I. New York: Academic Press.

Miller, E. 1991. Investing in a Drug-free Workplace. HR Magazine May: 48-51.

Major, M. 1990. Employee Assistance Programs: An Idea Whose Time Has Come. Modern Office Technology 35: 76.

National Safety Council. 1992. Accident Prevention Manual for Business and Industry. Chicago, Illinois: National Safety Council.

Oppe, S. 1988. The Concept of Risk: A Decision Theoretic Approach. Ergonomics 31: 435-440.

Peterson, C., A. Semmel, C. Von Baeyer, L. Abramson, G. Metalsky, and M. Seligman. 1982. The Attribution Style Questionnaire. Cognitive Therapy and Research 3: 287-300.

Rafilson, F. M. and K. M. Rospenda. 1988. Concurrent Validation Study of the Safety Scale. ESI Research Abstract No. 5. Park Ridge, IL: London House Publishers.

Rategan, C. 1990. Its Time for Your Checkup. Safety and Health 141: 42-44.

Rotter, J. B. 1966. Generalized Expectancies for Internal Versus External Control of Reinforcement. Psychological Monographs: General and Applied 80: 1-28.

Scotti, M. 1986. How to Supervise a Positive Discipline Program for Safety. Professional Safety April: 25-27.

Seligman, M. E. P., L. Y. Abramson, A. Semmel, and C. Von Bayer. 1979. Depressive Attributional Style. Journal of Abnormal Psychology 88: 242-247.

Shain, M. 1982. Alcohol, Drugs, and Safety: An Updated Perspective onm Problems and their Management in the Workplace. Accident Analysis and Prevention 14: 239-246.

Sims, M. T., R. J. Graves, and G. C. Simpson. 1984. Mineworkers' scores for the rotter internal-external locus of control scale. Journal of Occupational Psychology 57: 327-329.

Slora, K. B. A. B. Bocian. 1991. Employee Safety Inventory (ESI): Reliability and Validity Summary. Park Ridge, IL: London House.

Slora, K. B., M. Boye, and J. W. Jones. 1988. Construct Validation Study of the Employee Safety Inventory. ESI Research Abstract No. 3. Park Ridge, IL: London House Publishers.

Slora, K. B. and J. R. Molcan. 1990. Psychological Organizational Risk Assessment: A case Study. Paper presented at the American Psychological Association/National Institute for Occupational Safety and Health (APA/NIOSH) Conference, "Work and Well Being: An Agenda for the 90's", Washington, D.C.

Smith, M. J., H. H. Cohen, A. Cohen, and R. J. Cleveland. 1978. Characteristics of Successful Safety Programs. Professional Safety 10: 5-15.

Sosis, R. H. 1974. Internal-external Control and the Perception of Responsibility of Another for an Accident. Journal of Personality and Social Psychology 30: 393-399.

Stevens, J. 1986. Applied Multivariate Statistics for the Social Sciences. Hilldale, NJ: Lawrence Earlbaum Associates, Publishers.

Tennen, H. and S. Herzberger. 1985. Attributional Style Questionnaire. Test Critiques 4. Kansas City: Test Corporation of America: 20-30.

Weiner, B. 1972. Theories of Motivation: From Mechanisms to Cognition. Chicago: Markham.

Weiner, B. 1974. Achievement Motivation and Attribution Theory. Morristown, N.J.: General Learning Press.

Wichman, H. & J. Ball. 1983. Locus of Control, Self-serving Biases, and Attitudes Towards Safety in General Aviation Pilots. Aviation, Space, and Environmental Medicine 54: 507-510.

Wuebker, L. J. 1986. Safety Locus of Control as a Predictor of Industrial Accidents. Journal of Business and Psychology 1: 19-30.

APPENDIX 1: THE THREE FACTOR ACCIDENT PREDICTION INVENTORY

The Three Factor Accident Prediction Inventory

Accident and General Locus of Control Scale

This survey consists of 24 items. For each item, there are two statements (A or B). Please read each statement carefully and select the one that you believe is most true for you. Please keep in mind there are no right or wrong answers.

1.A. In the long run, the accidents that happen to us are due to chance.

B. Most accidents are the result of unsafe actions, unsafe conditions, or both.

2.A. When I am evaluated, sometimes I cannot understand how my supervisors arrive at their conclusions.

B. There is usually a direct connection between my job performance and the feedback that I receive from my supervisor.

3.A. People earn the respect they deserve.

B. No matter how hard a person tries, their worth generally goes unrecognized.

4.A. Without the right breaks one cannot prevent accidents.

B. Capable people who fail to prevent accidents have not taken the proper precautions.

5.A. I have often found that if an accident is going to happen, it will happen.

B. Trusting to fate has never turned out as well for me as making a decision about following safe job procedures.

6.A. The person that is selected to be boss usually happens to be in the right place at the right time.

B. It takes ability, not luck, to be able to get people to do the correct things.

7.A. In the case of the well trained worker there is rarely if ever such a thing as a freak accident.

B. Many times safety requirements tend to be so unrelated to the job that following them is really useless.

8.A. A person that prepares well will rarely encounter an unfair test.

B. It is useless to prepare for a test since most times, questions are unrelated to the course work.

9.A. Bad luck is partly the cause for many unhappy things in peoples lives.

B. When a person experiences misfortunes, they are due to mistakes made.

10.A. Most people don't understand the extent to which work injuries are controlled by accidental happenings.

B. There really is no such thing as "bad luck".

11.A. One cannot be an effective leader without the right breaks.

B. A person that is capable of being a leader but fails has not taken advantage of their opportunities.

12.A. The average worker can have an influence in preventing accidents.

B. Accident prevention is the responsibility of supervisors and other people and there is not much the little guy can do about it.

13.A. I believe luck and chance play an important role in my life events.

B. I have the ability to control many of the events that occur in my life.

14.A. In my case, being in an accident has little or nothing to do with luck.

B. Many times we might just as well decide who will be involved in an accident by flipping a coin.

15.A. I have control over the events in my life.

B. Sometimes I feel that I do not have much control over the events in my life.

16.A. If accidents occur to me, it is my own doing.

B. Sometimes I feel that I do not have enough control over preventing injuries.

17.A. It is hard to know what can cause an injury.

B. Following the proper job procedures will determine if you will be involved in an accident.

18.A. Accidental happenings control many areas of people's lives.

B. There really is no such thing as "luck"

19.A. One of the major reasons why we have accidents is because people don't take enough interest in safety.

B. There will always be accidents no matter how hard people try to prevent them.

20.A. Preventing an accident is a matter of following safe job procedures, luck has little or nothing to do with it.

B. Being in an accident depends mainly on being in the right place at the right time.

21.A. When dealing with supervisor and employee relations, unfairness does not exist.

B. Workers do not realize how much their jobs are influenced by accidental happenings.

22.A. With enough effort, I can prevent work related injuries.

B. It is difficult to have much control over the things that cause accidents.

23.A. Wars generally occur because people do not take enough interest in politics.

B. Wars will always occur no matter what people do to try and prevent them.

24.A. It is hard to affect a person's opinion about me.

B. How a person thinks of me depends upon how I act.

Safety Program Influence Scale

1. Does the disciplinary policy cover safety infractions?

2. Has employee training been provided on the topic "Accident Investigation"?

3. Is there a return to work policy in place for employees?

4. Is there an employee assistance program available to employees?

5. Are there procedures for conducting hazard surveys on a monthly basis with follow ups?

6. Are employees trained on the use of power equipment? (If the organization receives 90% of the points for documented equipment training and safety rules, then the question should be scored as a "yes")?

Scoring the Accident Prediction Inventory involves assigning a "1" for all internal answers obtained on the Accident Locus of Control Scale and a "1" for all safety programs that are present in the workplace that appear on the Safety Program Influence Scale. Total Inventory scores are derived by summing all points attained on the two scales.

APPENDIX 2: Three Factor Accident Prediction Inventory Scoring Procedures

Three Factor Accident Prediction Inventory Scoring

Locus of Control Scale

The following table depicts the "Internal" responses for the Three Factor Accident Prediction Inventory's Locus of Control items. A "1" was assigned to the subjects score if the identified statement was chosen. If the "External" item was chosen, a "0" was assigned.

Item	"Internal" Response	Item	"Internal" Response
1.	B	13.	B
2.	B	14.	A
3.	A	15.	A
4.	B	16.	A
5.	B	17.	B
6.	B	18.	B
7.	A	19.	A
8.	A	20.	A
9.	A	21.	A
10.	B	22.	A
11.	B	23.	A
12.	A	24.	B

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The dissertation is, therefore, accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

4/8/93
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