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Predicting employee compliance with safety regulations, factoring risk perception

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PREDICTING EMPLOYEE COMPLIANCE WITH SAFETY REGULATIONS, FACTORING RISK PERCEPTION

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Yenny Fariñas Diaz

2000

To: Dean Gordon R. Hopkins
College of Engineering

This thesis, written by Yenny Fariñas Diaz, and entitled Predicting Employee Compliance with Safety Regulations, Factoring Risk Perception, having been approved in respect to style and intellectual content, is referred to you for your judgment.

We have read this thesis and recommend that it be approved.

Michelle Marks

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The thesis of Yenny Fariñas Diaz is approved.

Dean Gordon R. Hopkins
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Florida International University, 2000

DEDICATION

I dedicate this thesis to my family and friends who have supported me throughout life, and my professional career.

Thanks for your patience, unconditional love, and understanding.

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I would like to thank the members of my committee for their time and guidance throughout my thesis work. I would also like to thank those at the manufacturing company that facilitated this study. Finally, a special thanks to my major professor Dr. Marc L. Resnick for his encouragement, advice, and continuous support throughout my graduate career.

ABSTRACT OF THE THESIS

PREDICTING EMPLOYEE COMPLIANCE WITH SAFETY REGULATIONS,

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by

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The purpose of this research was to develop a methodology that would evaluate employees' personality traits, demographic characteristics, and workplace parameters to predict safety compliance along with the moderating effect of risk perception.

One hundred and twenty five employees of a manufacturing facility were given questionnaires to gather their demographic and perception information. Surveys were also used to measure their personality characteristics, and periodic observations were recorded to document employee's safety compliance. A significant correlation was found between compliance and the worker's perception of management's commitment to safety ($r = 0.27$, $p < 0.01$), as well as with gender ($r = -0.19$, $p < 0.05$). Females showed a significantly higher average compliance (78%), than males (69%). These findings demonstrated the value of developing a model to predict safety behavior that would assist companies in maintaining a safe work environment, preventing accidents, ensuring compliance, and reducing associated costs.

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I. INTRODUCTION

In industry today the cost of work related deaths, injuries, and related costs exceeds $110 billion annually (Moeller, 1997). About 20 million workers in the United States are employed in manufacturing, and almost 500,000 cases of job related illnesses are estimated to occur annually. Industrial accidents account for 3.2 million disabling injuries, and 9,000 deaths (National Safety Council, 1996). The US Department of Labor determined that the overall incidence rate of occupational injuries in the United States increased 10% from 1983 to 1992 (US Department of Labor, Bureau of Labor Statistics, 1995a) and that there are an estimated 6 million reported occupational injuries in any given year in the United States (US Department of Labor, Bureau of Labor Statistics, 1995b). According to the National Safety Council (1996), in 1995 the national occupational injury and illness incident rate was 9.01% of full time employees, where the source of employment was: 12.34% from the Manufacturing Industries, 8.28% from health service, and 9.26% from public administration.

In an analytical epidemiological study of occupation injuries, Sorock and Courtney (1997) made the case that there has been limited progress in occupational injury prevention in the previous decade. They cite this because even though the US Department of Labor data suggests that recent fluctuations in occupational injuries indicate a potential leveling in overall incidence rates (US Department of Labor, Bureau of Labor Statistics, 1995b), there remains a stable volume of occupational injury in the United States. Of significance, insurance data indicate that people in certain relatively high-risk occupations such as agriculture, construction,

mining, and quarrying still have three to four times the average death rate for all industries. (Moeller, 1997).

Due to the many hazards that employees face in a modern workplace, companies find that the need to protect themselves as well as their employees has risen. The Occupational Safety and Health Administration (OSHA) was formed to encourage the reduction of workplace hazards, and to develop and set mandatory Safety and Health Standards (Moeller, 1997). Through the efforts of OSHA the attention of companies on safe practices has risen steadily. A realization that safe workplaces lead to higher productivity has also increased companies' attention to safe practices.

Predicting Safety Compliance

Due to a) recent injury and accident volume and rates, b) moral/ethical implications, and c) the staggering industry costs associated with injuries, it would be beneficial for a company to have a model that can be used to predict employee safety compliance. The model should be based on readily accessible company data, validated, and used to pro-actively reduce the occurrence of injuries/accidents that are due to lack of compliance.

The occurrence of occupational injuries in the United States has increased over the years and has been established as a costly operating expense. Generally, in order to prevent the occurrences of injuries and reduce associated expenses, safety programs are implemented that promote safe behavior by rewarding or punishing workers based on the actual occurrence of reportable injuries. However, to ensure the effectiveness of these programs, it is crucial to

monitor compliance with safe behavior, as this is a more proactive measure in avoiding the injuries in the first place.

Lack of compliance with safety regulations in manufacturing environments is likely to lead to work related injuries. There are distinct implications of non-compliance for both employees and employers. Employees may be subject to potential health and safety hazards in addition to loss of wages. Companies are subject to fines and penalties from regulatory agencies, in addition to the loss of productivity from injured employees. Compliance in general can be defined as employees' and employers' adherence to previously established safety requirements. Mandatory safety standards are often violated by employees as well as employers. Even when companies establish strict safety programs, ensuring employee's compliance with established rules is difficult to control. Thus some companies resort to the implementation of incentives, rewards, and disciplinary programs to ensure compliance. Even if mandatory programs required by the Federal Government are implemented by the employer, if employees fail to comply with them (e.g.: failure to wear proper PPE), the company is at fault, liable, and subject to penalties. Therefore, it is in the best interest of the employer for the employee to comply with the established regulations.

A Predictive Model of Safety Compliance

Identifying and monitoring the factors that affect individual safety behavior is important in the prevention, management, and control of work related injuries. For a compliance model, factors that should be evaluated to determine how they affect compliance are: age, gender, risk perception, past and present history of injuries, perception of physical exertion associated with

each job function, perception of management commitment to safety, and tenure (number of years at current job task).

In contrast with previous studies, this model has been developed using a cohort study where the exposure is known prior to the effect. A cohort study is often the best approach for inferring a cause and effect relation (Sorock and Courtney, 1997). This model can be used as a tool in preventing injuries by identifying the exposures or risks associated with a particular task or environment that influence compliance behavior.

A beneficial feature of this model for a company is that it can be executed at minimal cost so the cost savings will outweigh the initial expenses. The initial expenses that a company would incur in the implementation of this model would be minimal, such as collecting and evaluating company data and conducting surveys of existing employees. As a result, this model can be used as a tool to proactively prevent work related injuries and insure regulatory compliance, both of which lead to a reduction in associated costs.

Companies would also benefit by being able to place existing employees in jobs with risk levels that are proportional to their expected compliance. Also, it would allow the employer to predetermine which employees may require a higher degree of training and coaching prior to commencement of hazardous jobs.

A unique aspect of this model is that the influence of risk perception is factored into the prediction model (see Figures 1 and 2). This will address whether each parameter has an effect on compliance or if an effect moderated by perception as it affects compliance exists. The evaluation of risk perception as a moderating variable adds a new and potentially revealing

perspective to the prediction method that may not otherwise be evident. The moderation of risk perception between key parameters and behavior has significant implications for understanding worker behavior and the development of intervention strategies.

Figure 1

Typical Compliance Model

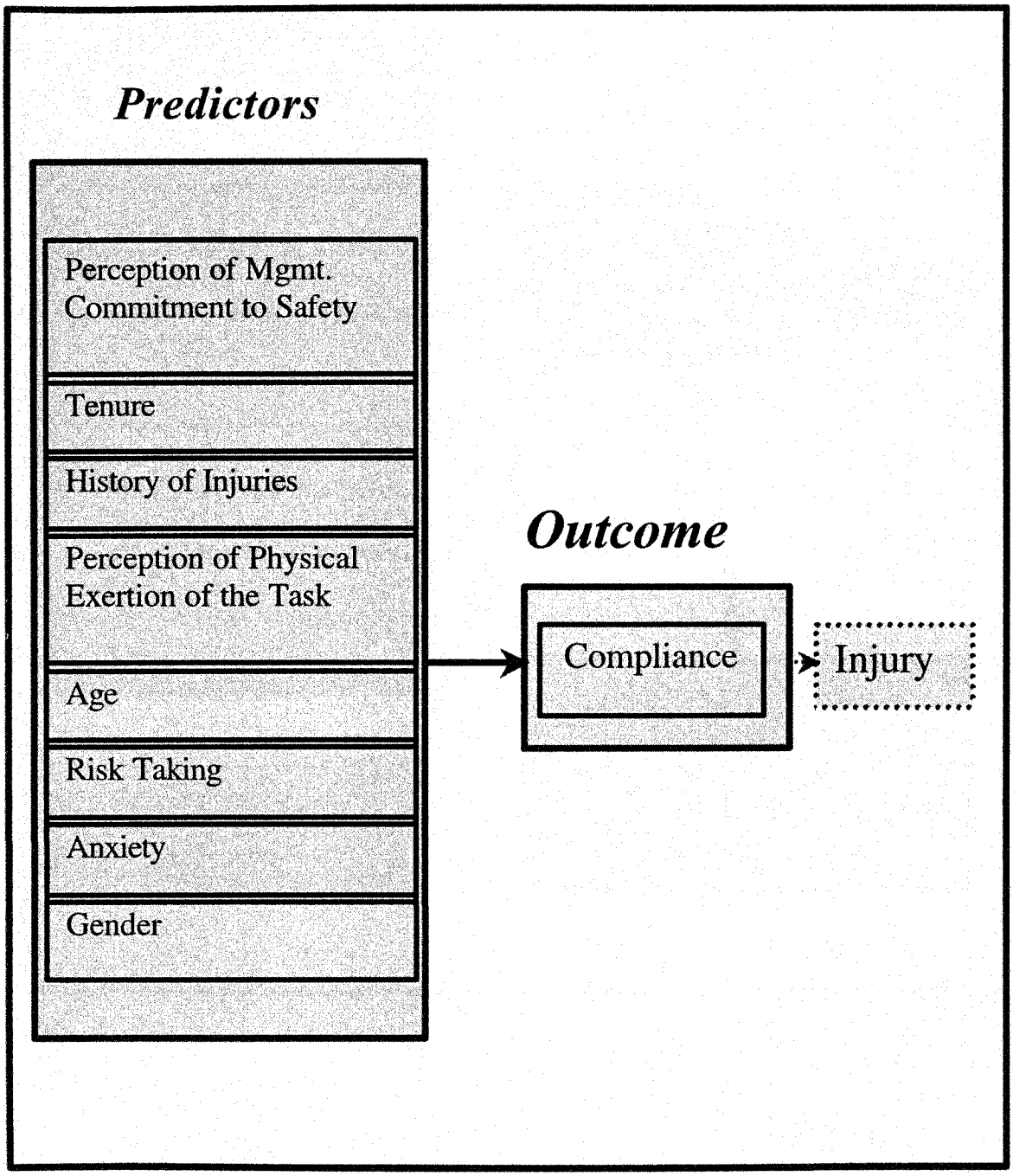
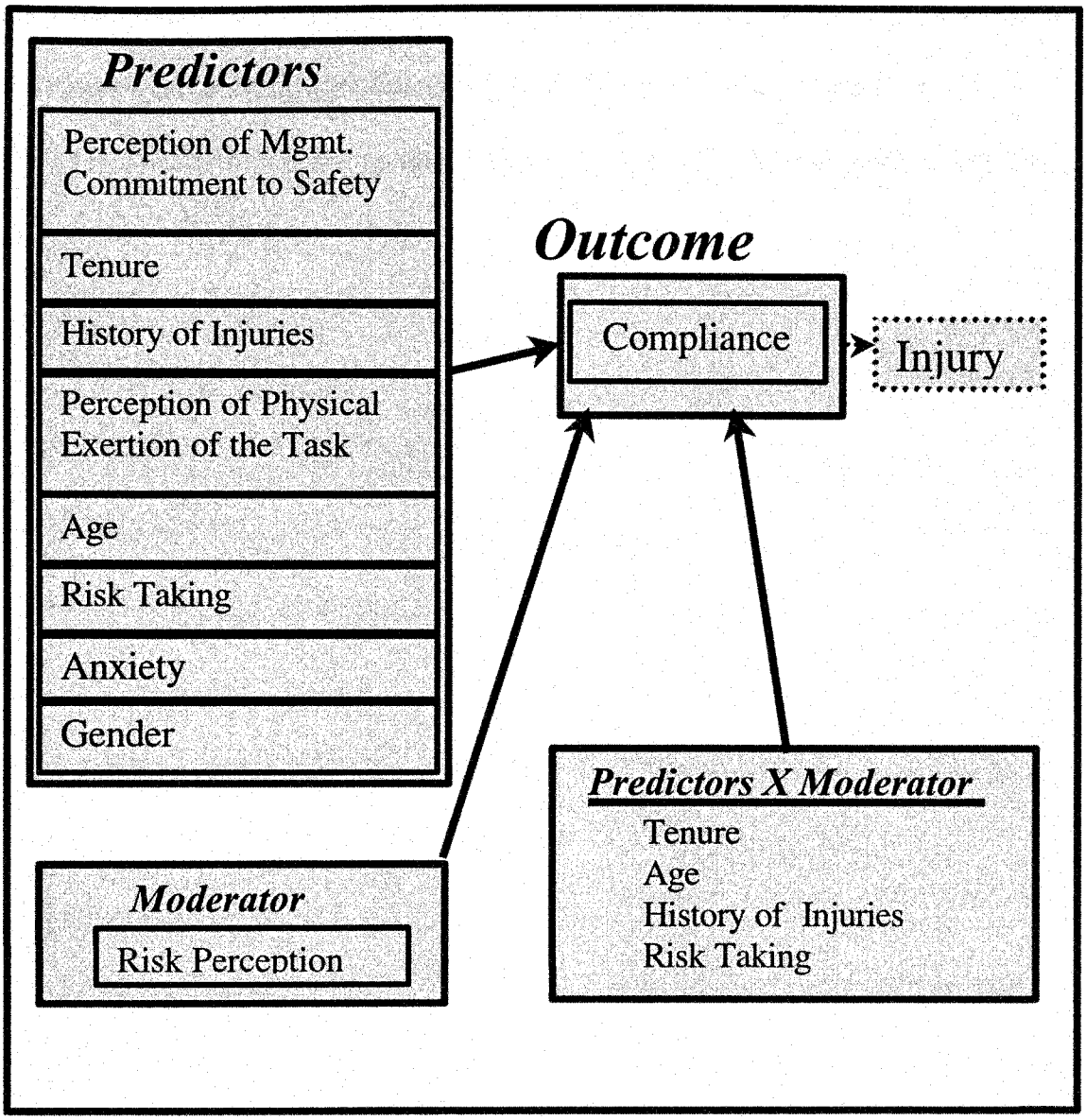


Figure 2

YFD's Compliance Model



Problem Statement

Workplace parameters, personality traits and demographic characteristics of an individual can influence his/her behavior, thus affecting compliance with safety regulations. This study focused on determining/predicting the likelihood of an individual's compliance by measuring the effect of job, demographic and personality factors on risk perception and injuries.

II. LITERATURE REVIEW

There are many factors that determine a worker's risk of a workplace injury, including his or her personality traits, age, gender, tenure, history of injury, perception of physical exertion of the job, perception of management's commitment to safety, and job satisfaction. Each of these can contribute to workers' safety related behaviors. Evaluation of these factors is significant towards understanding the implications for risk analysis, risk evaluation, risk communication, and their impact on safety behavior. The study of these factors is important because it: a) allows an evaluation of common potential risks as perceived by employees' in the corporate world; b) facilitates an explanation of trends and/or isolated incidents, c) identifies and evaluates behaviors that could lead to potential health and safety hazards, and d) explains their correlation with perceptions which may ultimately increase people's awareness, responsiveness, and comfort with safety regulations in a company.

Existing research describing the relationship between each of these factors and safety behavior will be described in the sections below.

Definition of Risk and Injuries

The National Safety Council defines an injury as an occurrence of bodily harm, such as a broken leg or a cut. They define an accident as the cause, such as a blow to the body or an episode of excessive or improper lifting (NSC, 1994). Accidents have also been defined as unplanned or unforeseen serious events that may be caused by physical environmental changes, behavior of individuals that have had previous accidents and individual causes such as attention, personality traits, and lack of knowledge (Dahlback, 1991). Because of the perception that

accidents are random events and thus cannot be avoided, the use of this term is often discouraged.

Hellesoy, Gronhaug & Kvitastein (1997) defined hazard as some foreseeable or believed danger often associated with severe or fatal consequences outside the control of the individual. So a worker with more control of a hazard may have a lower risk perception than another worker with the same hazard knowledge and exposure but with less control.

Risk is defined by Ayres, Wood, Schmidt, and McCarthy (1998) as "the possibility of suffering harm, encompassing both the nature of undesirable consequences from a choice as well as the likelihoods of these consequences". Sjoberg (1997) refers to risk perception as a judgment that there is a risk of a certain size at hand.

Worker Characteristics and Behavior

Several worker characteristics may have a significant effect on how workers perceive the risks of their jobs. Characteristics that have been hypothesized to affect behavior include risk taking, anxiety, age, gender, tenure on the job, history of injury, and risk perception.

Risk-Taking

Risk-taking is a personality trait that has been found to have an effect on behaviors that lead to workplace injuries. Dahlback (1991) defines accident proneness as the tendency of an individual to make decisions that lead to injurious consequences and to make decisions that lead to consequences not planned or foreseen. He determined that individuals who are bold have more injuries than those who are cautious, thus establishing a relationship between risk-taking and injury. Additionally, according to the Jackson Personality Inventory Manual (Jackson,

1967, 1974, 1984, 1989) individuals who are risk takers and enjoy gambling and taking chances enjoy adventures and are less concerned with danger, thus are more likely to be at risk of being injured.

A study by Salminen and Heiskanen (1997) also addressed the theory of risk taking behavior. They stated that some people exhibit behaviors that increase their likelihood of injury, even in the same conditions. That is, risk-taking behavior is presumed to be a stable personality trait. Salminen and Heiskanen (1997) state that people have a stable level of risk that they are ready to accept. Salminen and Heiskanen's study highlighted the fact that risk perception is generally present, so if a worker is habituated to risk from one aspect of the job, the risk perception may be transferred to another area. Thus the aspects of risk perception that lead to compliance need to be factored into any model.

Additionally, the effect of risk-taking personality on compliance was evaluated by Ortiz (1999). He conducted a study to evaluate the effects of user characteristics and product familiarity on behavior in order for product designers to convey appropriate information in product warnings. Being able to identify the hazard-prone individual may enhance the understanding of hazard perception, thus allowing for the development of adequate information and training. He determined that there was a significant negative relationship between risk-taking personality and safety behavior, thus greater risk-taking personality traits decreased the likelihood of compliance (use of PPE).

Anxiety

Another personality trait that may affect risk perception is anxiety. Anxiety is defined in the Jackson Personality Inventory Manual as the tendency to worry over inconsequential matters, and become tense and more easily upset than the average person (Jackson, 1967, 1974, 1984, 1989). Therefore individuals who score high on the anxiety measure may be more likely to have higher perceptions of risks associated with their job.

Hellesoy, Gronhaug, and Kvitastein (1997) investigated whether some people are more prone to perceive hazards than others in the same work environment. They define anxiety as the extent to which people tend to worry. The results of their study revealed that the high hazard perceivers who were older and had longer work experience showed a significantly higher degree of anxiety. However no study has addressed the relationship between anxiety and risk perception or compliance with safety regulations.

Ortiz (1999) evaluated the relationship between the anxiety personality trait and safety behavior. He found no relationship between this personality trait and compliance (use of PPE).

Gender

In the modern workplace environment that it is increasingly gender diverse, it is important to consider this variable when evaluating compliance and work-related injuries.

Lindqvist, Schelp, and Timpka (1999) investigated gender aspects of work-related injuries in a Swedish municipality with population of 41,432 and employing 77% of the population in the manufacturing, trade, and public administration industries. Data was collected by age, gender, and occupation. Also, injury information and factors that influenced a work-

related injury such as machinery, tools, and noise were also recorded. A total of 4926 unintentional injuries were recorded, where males were found to have nearly four times the work-related injury rate of females in all work sectors except for the commercial sector. The results of this study show that with regards to work-related injuries and injury event patterns, females differ from males. The research states that gender constitutes a risk-factor for work-related injuries, specially where there is a gender segregated job market. Furthermore, they attribute these results to the fact that males generally engage in more dangerous jobs. Also, they found that young men had the highest rate of injuries, while female injuries were more evenly distributed across age groups.

Also, in a survey by Yu, Liu, Zhou, and Wong (1999), occupational injuries in Shunde City (China) were recorded for 602,533 person years over a period of five years. They describe the city as one of rapid economic change and industrial development where injuries and fatalities had increased from 1989 to 1993. A total of 981 injuries and 159 fatal injuries were recorded, resulting in an injury rate of 1.63/1000 per year, and a fatal injury rate of 0.26/1000 per year. Their results indicated that males had a lower (major) injury rate than females, however females had twice the male fatality rate. Major injuries were defined as those with 105 or more working days lost. Furthermore, in contrast with previous studies, they attribute this unusual finding of a high fatality rate among females to the on-going migration of young females that for economic reasons were willing to engage in more dangerous jobs, and with lack of training and experience.

In agreement with previous studies that address the increasing fatality and work related

injury rate among males, Rabi, Jamous, AbuDhaise, and Alwash (1998) found a similar gender relationship. They determined that in Jordan, the majority of the fatalities were males, accounting for 98%, and that the overall fatality rate in men was 9 times greater than in women. However, they report that men accounted for 85% of the work force.

Age

The average age of the working population and the proportion of aging workers have increased over the last few years in most industrialized countries (Chi and Wu, 1997). They state that this is due to economic reasons, as aging workers prefer or have to sustain themselves. Also, the American work force is aging, where the median age of employees in the United States has increased from 34 years in 1984, to 39 years in 2000 (Mangino, 2000). Therefore, evaluating the effects of age on work-place injuries plays an important proactive role in setting the grounds for developing interventions, establishing future practices, and targeting resources. It is estimated by the Bureau of Labor Statistics, that an increase in older civilian employees will take place in the next several years. Mangino (2000) predicted that changes in the age of the work force have implications for injury rates. This is because generally aging employees (50 or older) have chronic physiological conditions that place them at increased risk for job related problems that may affect their performance. Thus she addresses the need to understand the impacts of age changes on safety issues and modifications of job specific requirements to accommodate age related changes and chronic conditions of the older workforce.

Consideration of age in the workforce has been a controversial subject as in the past it

has been used discriminatorily to exclude certain age groups from employment and in pre-placement assessments. As summarized in a study conducted by Nachreiner, McGovern, Kochevar, Lohman, Cato, and Ayers (1999), the passage of Title VII of the Civil Rights Act of 1964, the Age Discrimination in Employment Act of 1967, the Rehabilitation Act of 1973, the Immigration Reform and Control Act of 1986, the American With Disabilities Act of 1990 (ADA), and the Civil Rights Act of 1991 have shaped the current system of pre-placement assessments by prohibiting discrimination in hiring a qualified individual with a disability.

A worker's age may also affect his or her safety behavior. A retrospective study by Rabi, Jamous, AbuDhaise, and Alwash (1998) studied occupational injuries in Jordan that resulted in fatalities. Jordanian employers insured by the Social Security Corporation (SSC), accounting for about 72% of the total workforce, were studied. Non-insured employers (shops with less than five employees) were not part of the study. A total of 705 cases of fatal occupational injuries were studied, resulting in an overall fatality rate of 25.5 /100,000 per year. They determined that the risk of fatal injuries increased with age, where the highest fatality rate were workers aged 56 years and above. A different review of fatal occupational injuries conducted by Chi and Wu (1997) addressed the importance of age on injuries. They discuss a study by Laflamme and Menckel (1995) who suspected that aging workers were less capable of performing tasks and more liable to experience injuries. In order to confirm the effect of age (preventive or aggravating) on injuries, the occupational risks of the different age groups had to be evaluated simultaneously with other factors. Some of these factors are: the type of industry, gender, the number of workers employed by the company, the level of experience of the

worker, the source of injury, and the injury type. For the purpose of this review, only the results related to age will be discussed. The results of the studies reviewed by Chi and Wu indicate a higher frequency of injuries among older workers compared to younger workers. They concluded that management must develop strategies for workers in jobs in which age has a preventive or an aggravating effect on injury risk.

A review of scientific literature on age-related accident risks conducted by Laflamme and Menckel in 1995 (also addressed in Chi and Wu, 1997) summarized that age has either a preventive, an aggravating, or no effect on accident frequency and severity. Age-related accident severity was found to increase with age and to represent a negative factor in occupational performance and accidents for age impaired activities. They found that there was a positive relationship between an increase in accident rates and a decline in occupational performance with age. They found age and experience to be beneficial to the employee early in their career, but detrimental after a certain age. On the other hand, even though not verified statistically, they said that experience was a significant factor related to fatal injuries and age. Therefore, they state that if skills and experience accounted for the declining trend in the relationship between age and accidents at younger ages then functional decline was responsible for the rise in injuries at the later ages. They attribute fatalities among aging employees potentially to their slowness in escaping from injuries, a general lack of physical strength, and less flexibility to adjust posture to regain balance. And those fatalities on young workers were suspected to be due to inexperience and carelessness.

Chi and Wu (1997) also conducted an empirical review of occupational fatalities in

Taiwan to compare the effects of age and other contributing factors on the risk of fatal injury. The research consisted of a review of incident reports from 1230 work-related fatalities in the years 1989, 1990, and 1992. The results of their study with respect to the effect of age indicated that workers aged 55 and above had the highest fatality rate in the construction, transportation, communication, commerce, and service industries. Comparisons across several age groups indicated that workers aged 55 and above had the highest aggregated (overall) fatality rates and disaggregated (categorical) fatality rates for half of the incident types and that age had some impact on all incident types. In contrast, in the mining and quarrying industry, younger workers had a greater aggregated fatality rate. Therefore the interaction between age and task on risk perception and behavior must be determined.

These results are also consistent with those reported in a study by Jeong (1998). Jeong (1998) investigated 3028 occupational deaths and 125,929 injuries in the construction industry of South Korea to identify patterns of occurrence by company size, age of the injured person, work experience, accident type, injury type, injured part of body, and agency of accident. Their age-related results revealed that as in similar studies, the risk of fatal and non-fatal injuries in the construction industry increased with age. Workers 45 and older had higher incident fatality rate attributed to industrial accidents than younger workers. Furthermore, they determined that workers often sustained injuries during their first year of service, where 95.6% of non-fatal injuries and 92.5% of fatalities took place during that first year of employment. Jeong (1998) suggests that his findings might be justified by previous studies by Baker (1987) and Rabit (1991) which suggest that the age–injury rate relationship is due to poor motor

coordination, lack of mental agility, sensory deficiencies, and longer learning time or adaptability. However Jeong (1998) also suggests that his findings contrast with those of Nicholson (1985) and Baker (1987) where younger workers are said to have more injuries due to inattention, impulsiveness, over estimation of capacity, pride, recklessness, and lack of family responsibilities. Finally, Jeong attributes the high incident death rate in the elderly to age because even if they incur an injury with the same severity rate as a younger employee, their injuries are still more likely to have fatal consequences.

Tenure on the Job

Tenure on the job is generally defined as the number of years a worker has been employed by the same company. Previous studies have identified a direct relationship between tenure and injury. For example, Chi and Wu (1997) cite a study by Bustani (1988) that measured significant differences in the risk of injury depending on workers' job experience in the following categories: less than 1 year, 1 to 15 years, and greater than 15 years in a company. It was discovered that injury risk varied more by experience than by age. They found that workers with one year or less experience were at higher than average risk, while those with more than 15 years of experience were at lower than average risk.

Management Issues

Management issues such as a worker's dissatisfaction with the work environment or perception of management's commitment to safety can affect the individual's perception of hazards, risk, and subsequent behavior. Workers with negative perceptions of these issues may have a poorer safety attitude and be more likely to experience an injury. For example, a recent

study by Kirschenbaum, Oigenblick, and Goldberg (2000) found that those employees with a frequent history of injury attributed it to a lack of safety conditions pointing toward unsafe technologies and management practices.

In contrast, if management displays a strong commitment toward safety enforcement, workers may be more likely to comply with safe behaviors. The effect of management issues on risk perception, however, is more complex and needs to be evaluated carefully. Studies by Fleming, Flin, Mearns and Gordon (1997) objectively demonstrated that as the working environment changes, the worker's risk perception also changes. Workers' perception of their risk exposure is correlated with satisfaction with safety measures, which increases for improved working conditions that are unrelated to safety. For example: An employee working in a non-air conditioned environment will perceive higher risks and have more dissatisfaction with safety measures than one working in a well-ventilated area, even if the temperature difference does not create a safety risk. Organizational factors such as management commitment to safety influence the worker's choice of behavior. An employee may choose to take chances when the company has not provided the worker with the necessary tools to perform the task safely. Or when workers perceive that management prefers productivity to safe behavior, they may assume that it is in their best interests to trade off safety for productivity. A worker may also be less careful if they trust that management has eliminated any hazards from the job. Few of these premises have been tested in empirical research.

Moderating Effects of Risk Perception

A model that describes the relationship of worker characteristics and safety behavior

must identify the moderating effects of risk perception. According to Baron and Kenny (1986), "a moderator is a qualitative (e.g., sex, race), or a quantitative (e.g., level of reward) variable that affects the direction and/or strength of the relationship between an independent or predictor variable and a dependent or criterion variable". Thus some workplace parameters or worker characteristics may have a predictive effect on safety behavior, while other variable's predictive behavior may be moderated by risk perception. The following sections describe studies that investigated the effects of several worker characteristics on risk perception.

Actual Risk Exposure

The factor of risk perception is an employee's subjective opinion of the degree of hazards associated with his/her job. It is referred to by Sjoberg (1997) as a judgment that there is a risk of a certain size at hand. Perceptions of risk may be determined by the actual likelihood of an injury. This depends on the ability of the workers to accurately estimate the likelihood of injury from specific job tasks. Fleming, Flin, Mearns and Gordon (1997) studied the accuracy of workers' risk perceptions with regard to specific hazards. A total of 622 workers on oil and gas platforms were administered a questionnaire. The questionnaire included questions on demographic and job characteristics, perceived risk, safety attitudes, safety satisfaction, and accident/injuries.

They matched these characteristics with major hazards, injury frequency, and lost time injuries. They used Quantitative Risk Assessment (QRA) to determine the accuracy of the person's perception of the risk compared to the actual safety risk and injury involvement to which they were exposed. Working environment, management commitment, and safety attitudes were

included as independent variables. Safety satisfaction, job situations, and risk perception were the dependent variables.

The results of their study contradicted previous research in that they concluded that workers have reasonably accurate perceptions of the risks from major and individual hazards. They concluded that even though most people perceive risk in a very subjective manner, the risk perception of the workers were reasonably accurate when comparing their subjective risk perception with the objective risk measurements previously discussed. They conjecture that this contradiction in results is due to the fact that previous work focused on risk perception with respect to specific work situations while they focused on perceptions based on specific hazards.

In contrast, Borg (1998) states that human perception can bias the results of test data that is related to physical exertion where the subject's judgment might be distorted due to a general error in the perceptual process. Borg claims that the perception of exertion at very high intensities is also connected with diminishing working capacity, but at low or moderate intensities may be related to a state of activation, which has a positive effect on performance. Therefore, he states that exertion and fatigue are states with both physiological and psychological aspects, where the perception of exertion is a result of physiological cues (sensations from the muscles and joints, somatosensory receptors from the cardiovascular and respiratory systems) and psychological cues (memory of work situations, actual performances, and the emotions associated with it). Therefore, risk perception and performance may be influenced by a combination of both psychological and physiological factors because in some cases the situation in which the work is performed may suppress some sensations that may cause the subject to

attend to and concentrate on other sensations.

Affect

In analyzing risk perception, it is important to recognize the difference between emotional and cognitive reactions to risks and hazards. Emotional reactions are those ruled by the emotional state of the person (i.e. pessimism) and cognitive reactions to risk are based on injury likelihood (e.g., risk associated with traffic). It is very difficult to distinguish between the two because a person that is worried may be worried because he/she is considering that there is a risk at hand. Therefore, it is important in research to be able to distinguish between emotional and cognitive factors.

Hellesoy, Gronhaug and Kvitastein (1997) conducted a study of the potential effects of affect and emotions on risk perception. The subjects consisted of 205 catering workers on a drilling platform at a continental shelf in the North Sea. A written survey was provided to all catering personnel. The study found that workers with higher levels of burnout, anxiety and depression perceived higher hazards, even in the same environment. Additionally, the findings indicated that emotional state and negative feeling about the job increased the individual's perception of hazards. Demographic characteristics including gender, marital status, age and working experience had very little or no influence on workers' perceptions of risk.

Sjoberg (1997) conducted a study to determine the correlations between risk perception and worry, where worry is defined as denoted preoccupation with thoughts about uncertain and unpleasant events, and risk perception is referred to as a judgment that there is a risk of a certain size at hand. The purpose of this study was also to determine the relationship

between worry and perceived risk when measured separately. The study consisted of 1224 questionnaires distributed to a random sample of Swedes. One survey was focused on measuring the perceived risks of solar radiation while the other measured different levels of worry correlated with personal and general risk. In contrast with Hellesoy, Gronhaug and Kvitastein (1997), the results of this study indicated that there was a weak correlation between perceived risk and worry. Also, they found that even when the respondents experienced high levels of personal risk, worry (for all participants and all categories of hazards/risks) was moderate. According to Sjoberg, this can be attributed to risk denial or lack of control because a person can be worried about a risk without believing that it is large and vice versa. Sjoberg suggests that there is a distinction between cognitive (abstract) hazards and concrete (sensory) hazards, and that both affect the worry-perceived risk relationship. He defines cognitive (abstract) hazards as those that deal with abstract threat and for which we do not have sensory information or sensory memories.

Therefore according to this study, cognitive hazards do not have a direct connection to our emotional system. They are said to elicit cognitive perceptions of risk but are not the primary cause of worry. On the other hand, Sjoberg (1997) states that concrete (sensory) risks are those that are negligible from a cognitive perspective, but cause a person to worry because they awaken people's anxiety in moments of perceived risk. Also, even though the study indicated that there was a modest relationship between risk perception and worry, it was concrete risk that determined worry.

Other studies by Rundmo and Sjoberg (1997) assessed the difference between

perceived risk and the evaluation of the risk source. They defined perceived risk as an individual's attitudes and beliefs towards a risk source. The source of risk may be the likelihood that the platform of an oil rig may sway, thus causing an injury. The risk perception is the worker's attitude and belief that this may occur. When the magnitude of the risk perceived corresponds to the actual risk, there is a strong correlation between risk perception and the risk source. However, when people's perceptions of risk are not equal to the actual risk, then the two measures are not equal.

A total of 179 workers on an offshore platform installation during bad weather conditions were asked to complete a questionnaire that covered personal background information, work experience, evaluation of risks involved with the platform movement, and experiences of risks related to platform movement (Rundmo and Sjoberg, 1997). The purpose of the study was to measure risk perception caused by the actual hazard itself (platform movement), to evaluate workers' attitudes towards the perceived risk, to determine the desired risk communication and finally to contrast two models of risk perception: a mental imagery model and a rationalistic model. According to Rundmo and Sjoberg (1997) the rationalistic approach proposes that worry, concern, and risk perception are influenced by the worker's evaluation of the platform movement. The mental imagery approach predicts the effect in the opposite direction, that worry and concern affect the evaluation of the platform movement. The results of the study revealed that the great majority of the participants showed concern about the consequences of the platform movement rather than the tension and worry caused by the movement itself. When workers received information about the risks associated with their work

environment, their worry was reduced. Thus it is critical for any study to consider the specific relationships among parameters and the directions of these relationships when proposing any predictive model.

Compliance

Previous studies have centered on studying the effects of personality traits and work characteristics, and their effect on risk perception and injuries. Much less research has been documented on a more proactive approach that establishes links between work characteristics and compliance in an effort to prevent injuries.

III. OBJECTIVE AND HYPOTHESES

Objectives

The objective of this research was to develop a model to predict the safety compliance of employees based on specific characteristics of the worker and workplace. The research attempted to distinguish between factors that effect safety compliance, and those factors, whose effect on compliance are moderated by risk perception. Factors that were included in the model are: perception of management commitment to safety, experience /tenure (number of years in the job with the company), history of injury, perception of physical exertion associated with the particular job tasks, age, gender, risk-taking, anxiety, and risk perception.

This model was validated in an actual workplace to verify its effectiveness. The model identified employees who possess the characteristics and risk perceptions that lead to non-compliance. Non-compliance increases the risk of injuries so this model can be used as a proactive intervention to reduce the incidence of workplace injuries and to target safety-training initiatives.

Hypotheses

The hypotheses that were tested in this study are as follows.

Correlated effects on compliance:

1. Workers with a high perception of management commitment to safety, as measured on a five point-Likert scale, may be more likely to comply with safety regulations.
2. A high perception of physical exertion at the primary job task, as measured on a Borg CR10 scale, reduces compliance with safety regulations such as PPE.

3. Workers with a high degree of anxiety as measured by the Jackson Personality Inventory-Revised (JPI-R) are less likely to comply with safety regulations.

Effects moderated by risk perception:

4. Longer tenure of employment lowers perception of risk, and makes employees less likely to comply with safety regulations.
5. Employees with any history of a workplace injury have higher risk perception and thus are more likely to comply with safety regulations.
6. Older workers have a higher perception of risk and thus are more likely to comply with safety regulations.
7. Workers who are risk-takers have lower risk perception and thus are less likely to comply with safety regulations.

IV. METHODOLOGY

A study was conducted at a manufacturing facility, and a model that predicts employee adherence to safety related regulations was developed with the intended purpose of creating a predictive model for compliance. Compliance for this study was measured by the recorded use of personal protective equipment (PPE) as required in the employee's job description.

Participants

The participants were employees at a local consumer lighting manufacturing facility. The sample group was composed of 125 employees who were representative of four departments each with a variety of job functions (see Table 1). The age and gender of the employees was collected in the surveys and reflect the demographics of any general working population in a metropolitan area. The number of employees varied per department as well as their tenure in their functions within their department (see Table 2). Additionally, each function within each department had unique PPE requirements (see Table 3, and Appendix B). As expected, the surveyed employees included a wide variety of job tenure, risk perceptions, and history of workplace injury.

Materials/Tools

Task functions within each department required the use of specific personal protective equipment (PPE). Table 3 summarizes the PPE requirements for the departments and the associated tasks of this study. Photos depicting specified PPE are included in Appendix B, and sample PPE as used by employees is shown in Appendix C. The use of the specified PPE was a company policy and failure to comply with the use of such equipment constituted a corporate

safety violation.

The following is a summary of PPE requirements per departmental job tasks. Photos illustrating further details are included in Appendix B.

- Decorators: Belts, Apron, Nitrile gloves, Dust mask, Safety glasses
- Sprayers: Belts, Apron, Nitrile gloves, Respirators, Safety glasses
- Material handlers: Belts, Heavy duty gloves
- Assemblers: Safety glasses, Belts

Data Collection Surveys

Both objective (i.e. based on data such as accident frequencies, lost time, and self report accident involvement) and subjective (i.e. perceptions and thoughts) methods were used in order to obtain results representative of how workers perceived the levels of safety in the work environment, their safety attitude, and their safety satisfaction. In this study, surveys were utilized to collect information related to relevant variables. The survey had two parts: employee background and subjective measures. Employee background recorded the objective measures and the subjective section elicited workers' perceptions.

Employee Background

Surveys were used to record the employee demographics and work history/tenure. (Reference surveys in Appendix A). The surveys recorded the employees':

1. Past and present history of work related injuries: Past injury records a worker's history of work related injuries in both previous and current jobs. Any occupational injury that required medical treatment or lost time was included.

2. Job tenure (Number of years in the job with the company): The job experience of the workers was defined as the number of years in the current position at the manufacturing company.
3. Age: Age was reported in years.
4. Gender: Reported as male or female.

Subjective Measures

The second part of the survey elicited perceptions of the workers using 5-point Likert scales, a CR-10 Borg scale, and personality traits from the Jackson Personality Inventory - Revised. The characteristics that were measured are:

1. Perception of Physical Exertion: Perception of physical exertion was measured on a Borg CR10 scale shown in Appendix A. This scale was selected because of its reliability and validity in measuring perceptions of physical exertion (Borg, 1998).
2. Employee's Perception of Management Commitment to Safety: Employee's perception of management commitment to safety was measured using a five point Likert scale. (see Appendix A).
3. Risk Perception: Employee's perception of how much risk to their personal health and safety there is in their job was measured using a five point Likert scale (Appendix A).
4. Anxiety: Anxiety was measured using the JPI-R (see description in Table 4).
5. Risk Taking: Risk Taking was measured using the JPI-R (see description in Table 5).

Personality Traits

The Jackson Personality Inventory Revised (JPI-R) was used to evaluate employees' personal characteristics because of its acceptability in industry and its validated effectiveness in assessing individual characteristics (Jackson, 1967,1974,1984,1989; Wiggins, 1973). The JPI-R is a tool to assess personality variables that are likely to have an effect on people's behavior in environments such as the workplace. The JPI-R uses twenty True/False questions to measure each personality trait. The modules for Risk Taking and Anxiety were included as part of the survey given to participants in this study. The following list summarizes the definitions of the Risk Taking and Anxiety from the JPI-R scales.

Anxiety: Intended to assess mild to moderate manifestation of stress. A person scoring high on Anxiety may be viewed as being generally worrisome with regard to day-to-day activities and personally relevant events. A person scoring low on anxiety may be viewed as being unusually free from even the normal range of fears and uncertainties that affect most people from time to time.

Risk Taking: Has been considered to include four facets: physical, monetary, social, and ethical risk taking. Individuals who score high on this scale are prone to exposing them selves to situations having uncertain outcomes. Low scores prefer to be more cautious in their approach to things.

Procedure

Compliance

Employees' compliance was observed during the normal performance of their tasks. Recording methods were unobtrusive and discreet so that employees were in their true environment with no external influencing factors. They were not aware that their compliance was being observed.

All employees were required to use their PPE as part of the work requirements. However, a departmental inventory was conducted a week prior to the commencement of the evaluations to ensure that PPE was available throughout the survey period. The PPE was the same that had been used in the specified departments for at least five months. No new or modified PPE was introduced to reduce the potential for influencing employee behavior.

The participants' behavior was examined for compliance with the job specific PPE requirements. Each employee was observed on five separate occasions, each at random times. The employee was given a score according to the number of observations in which he or she was in full compliance. This adherence to 100% PPE usage is strict because any incident of non-use of PPE would be considered a violation by current Federal regulations.

Surveys

The surveys were distributed by the Group Leads and were collected by management. The Safety Engineering function did not distribute the surveys so as to prevent potential biases as a result of their presence. Surveys were distributed just before the workers took their lunch

break. This was a time when workers' perceptions should reflect the exertions required by their tasks.

Data Analysis

Descriptive Statistics and Correlations Among Study Variables

Means, standard deviations, and minimum/maximum scores of the independent variables (Tenure, Age, History of Injuries, Perception of Physical Exertion of the Task, Perception of Management Commitment to Safety, JPI Anxiety, JPI Risk Taking), as well as the Dependant variable (Compliance), and Hypothesized moderator (Risk Perception) are presented in Table 6.

In order to determine the relationship between the parameters that had an effect on compliance and those moderated by risk perception, correlations between each workplace parameter and compliance and between each workplace parameter and risk perception were calculated. A correlation matrix was calculated to test if any workplace parameter interacted with any other workplace parameter (see Table 6). Since both history of injury and gender are binary variables, T-tests were used to test the relationship between these parameters and compliance and risk perception (see Table 7 and Table 8).

Analysis of Variance and Post Hoc Test

A one way ANOVA and a Post Hoc test were conducted to determine the differences between all the variables within the four department groups (see Table 9).

Model Evaluation-Hypotheses Testing

To test the hypotheses necessary to evaluate the proposed model (see Figure 2), simultaneous regressions, hierarchical multiple regression analysis, and stepwise multiple regression were used. All of the independent variables were evaluated using these techniques.

1) Simultaneous Regression Analysis

In order to test the hypotheses that address the effects on compliance (Hypotheses 1-3), a simultaneous regression analysis using all the independent variables was conducted to predict compliance.

2) Hierarchical Regression Analysis

A hierarchical regression analysis was conducted to test the hypotheses that addressed the moderating effect of risk perception on compliance (Hypotheses 4-7).

3) Stepwise Regression Analysis

A stepwise regression analysis was conducted using the independent variables, as an exploratory method to search for a more practical model that explained more of the variance in compliance.

V. RESULTS

Descriptive Statistics and Correlations Among Study Variables

Significant Correlations Among the Variables and Compliance

As indicated in Table 6, pearson correlations among the variables revealed that two workplace parameters were found to be correlated with compliance. A significant correlation was found between the Worker's Perception of Management's Commitment to Safety and Compliance ($r= 0.27$, $p < 0.01$). Figure 3 shows this relationship graphically. Workers with higher perceptions of management's commitment to safety had higher compliance with PPE regulations than those who had lower perceptions.

A significant relationship was also found between gender and compliance ($r=-0.19$, $p<0.05$). Figure 4 shows this relationship graphically. Females had a significantly higher average compliance with PPE regulations (78%) than males did (69%).

Significant Correlations Among the Variables and Risk Perception

A significant correlation was found between tenure and risk perception ($r = -0.21$, $p < 0.05$). Figure 5 shows this relationship graphically. Workers with longer tenures in their current job task had lower risk perception than those who had shorter tenures.

A significant correlation was also found between perception of physical exertion and risk perception ($r = 0.30$, $p < 0.05$). Figure 6 shows this relationship graphically. Workers who had higher perceptions of the physical exertion of their current job task had higher risk perception than those who had lower perceptions of exertion.

Significant Correlations Between Workplace Parameters

Additionally, correlations among workplace parameters were determined to see if there were any other potential relationships between workplace parameters, which could also potentially affect compliance.

Seven significant correlations were found among the workplace parameters (see Table 6). Tenure was correlated with age ($r = 0.34$, $p < 0.01$). Workers who had been at their current job longer tended to be older than workers who had worked at their current job for less time. Tenure was also related to history of injury ($r = 0.29$, $p < 0.01$). Workers who had a previous injury had more work experience (4.9 years) than workers with no previous injury (2.8 years). A significant correlation was also found between perception of management commitment to safety and tenure ($r = -0.20$, $p < 0.05$). Figure 7 shows this relationship graphically. Perception of management commitment to safety slightly decreases with tenure.

A significant correlation was found between age and the perception of physical exertion of the task ($r = -0.22$, $p < 0.05$). Figure 8 shows this relationship graphically, where older workers had lower perception of the physical exertion of the task than younger workers did.

Additionally, a significant correlation was found between perception of management commitment to safety and history of injuries ($r = -0.25$, $p < 0.01$). Figure 9 shows this relationship graphically. Employees who had a history of injuries had a lower perception of management commitment to safety (mean of 3.56) than those who did not have a history of injuries (mean of 4.15).

A significant correlation was also found between gender and JPI anxiety score (r =

0.45, $p < 0.01$). Figure 10 shows this relationship graphically. A higher level of anxiety was found among males (mean of 50.7) than females (mean of 42.4).

Also, JPI risk taking score was negatively correlated with gender ($r = -0.44$, $p<0.01$). Figure 11 shows this relationship graphically. Females were found to have higher levels of risk taking (mean of 59.4) than males did (mean of 51.4).

One Way ANOVA and Post Hoc Test

A one way ANOVA test was conducted to determine the differences between all the variables within the four department groups. Then, where appropriate, Tukey post- hoc analyses were conducted to assess the significance of mean differences obtained from the ANOVA tests. The significant differences between the departments are highlighted in Table 9.

Results of the Post Hoc test indicated (see Table 9) that significant mean differences were found between the worker's tenure of the Metal Preparation and Finishing Departments (Mean difference=3.5, $p<0.01$). Differences in the scores of perception of physical exertion of the task were also found between the Pre-Assembly and Shades (Mean difference=4.3, $p<0.01$), and between the Shades and Finishing Department (Mean difference=3.3, $p<0.01$). Age differences were found between the Shades and Finishing Department (Mean difference=13.4, $p<0.01$). Significant differences were also found in anxiety scores between the Metal Preparation and Finishing Department (Mean difference=7.9, $p<0.01$). Finally, significant mean differences were also found in compliance scores between the Finishing and Shades Department (Mean difference=22.1, $p<0.01$).

The Analysis of variance conducted indicated significance between departmental group

variances for tenure ($F_{(3,124)}$=4.4, p<0.01), perception of physical exertion ($F_{(3,124)}$=5.5, p<0.01), age ($F_{(3,124)}$=6.1, p<0.01), anxiety ($F_{(3,124)}$=3.8, $p \leq 0.01$), and compliance ($F_{(3,124)}$=4.8, p<0.01).

Test of Hypotheses

Effects on Compliance

In order to predict compliance, a simultaneous multiple regression analysis was conducted. All of the independent variables of the study were entered simultaneously to determine the correlation of the best possible weighted combination of independent variables with compliance. Categorical variables such as gender, and history of injuries were recorded and entered as binary variables. The multiple correlation coefficient (R), using all the predictors simultaneously, was found to be 0.348, and an R^2 value of 0.121 was obtained. Thus, the model explained 12.1% of the variance in compliance, accounted by the combined independent variables, significant at the 0.05 level ($F_{(8,124)}$=2.0, $p \leq 0.05$). (see Table 10).

Hypothesis 1

Hypothesis 1 predicted that workers with high perception of management commitment to safety would be more likely to comply with safety regulations. A simultaneous regression analysis was conducted. The results of the regression revealed that the effect of Perception of Management Commitment to Safety on Compliance was significant (p<0.01, β=0.268), thus in support of Hypothesis 1. (see Table 10).

Hypothesis 2

Hypothesis 2 predicted that a high perception of physical exertion at the primary job task affects compliance with safety regulations. The result of the regression analysis did not support the hypothesis since worker's high perception of physical exertion at the primary job task posed no significant effect on compliance. (see Table 10).

Hypothesis 3

Hypothesis 3 predicted that workers with a high degree of anxiety are less likely to comply with safety regulations. The results of the multiple regression analysis showed that high degrees of anxiety were found not to have a significant effect on predicting compliance, thus not in support of this hypothesis. (see Table 10).

Also from the multiple regression analysis, it was concluded that other employee characteristics, such as employee's gender, age, tenure, history of injuries, and high risk taking yielded no significant improvement to predicting compliance. (see Table 10).

Workplace Parameters Moderated by Risk Perception

A hierarchical multiple regression analysis was used to test the moderating effect of risk perception between the workplace parameters and compliance.

The analysis was performed by first entering all the Independent variables of the study and calculating their effect on compliance. A significant relationship was achieved ($F_{(6,124)}=2.7$, $p<0.05$), where a multiple correlation (R) value of 0.348, and an R^2 value of 0.121 were obtained. Thus, the model explained 12.1% of the variance in compliance, accounted for by the combined independent variables (see Table 11). Furthermore, only the variables of Perception

of Management Commitment to Safety ($t=2.98$, $p<0.01$) and Gender ($t=-2.15$, $p<0.05$) were significant. Thus, this suggests that the evaluation of Gender and of Worker's Perception of Management Commitment to Safety is important in predicting compliance (see Table 11).

As a second step in the hierarchical regression, the variable of Risk Perception was introduced to determine its effect on compliance. No direct effects of risk perception were found. Introducing the risk perception variable did not significantly increase the variance explained by the model ($F_{(7,124)}=2.5$, $p<0.05$) (see Table 11).

Finally in the third step of the hierarchical regression, the interactions between risk perception and the independent variables were entered. No interactions, moderating effect, or significant increase of the variance predicted in compliance was detected when the interactions between risk perception and the independent variables were entered (see Table 11).

Hypothesis 4

Hypothesis 4 predicted that longer tenured employment lowers perception of risk and makes employees less likely to comply with safety regulations. The results of the hierarchical regression did not support this hypothesis (see Table 11). Tenure did not predict compliance, had no significant effect on the model, and introducing risk perception did not account for additional variance.

Hypothesis 5

Hypothesis 5 predicts that employees with any history of a workplace injury have higher risk perception and thus are more likely to comply with safety regulations. The results of the

regression analysis revealed that history of workplace injury posed no significant effect on the model, and thus did not support the hypothesis (see Table 11).

Hypothesis 6

Hypothesis 6 predicts that older workers have a higher perception of risk and thus are more likely to comply with safety regulations. However, this hypothesis was not supported by the results of the regression analysis because age posed no significant effect on risk perception in predicting compliance (see Table 11).

Hypothesis 7

Hypothesis 7 predicts that workers who are risk-takers have lower risk perception and thus are less likely to comply with safety regulations. The results of the regression analysis showed that low risk taking was found not to have a significant effect on risk perception in predicting compliance, thus this hypothesis was not supported (see Table 11).

Exploratory Method: Stepwise Regression Analysis

A stepwise multiple regression analysis was conducted as an exploratory method to determine if a more practical model that explains compliance equally well was feasible.

An F-test of significance was performed to determine which independent variables would significantly and better predict compliance in the sample population. Each variable was entered. Then at each step, R is computed to determine whether the independent variable entered adds significantly to the amount of variance in compliance that is predicted by the independent variables already entered.

A multiple correlation (R) of 0.328, and an R^2 value of 0.11 were obtained. Thus the model explained 11.0% of the variance in compliance, accounted for by the combined independent variables of gender and worker's perception of management commitment to safety, significant at $p<0.01$ ($F_{(2,124)}=7.4$, $p=<0.01$). The other independent variables of the study were not significant in predicting compliance.

Thus a more practical model for predicting compliance in the subject company would include only gender and perception of management's commitment to safety.

VI. DISCUSSION

Industrial accidents are a critical and costly problem affecting not just U.S. industries, but also the world. It is estimated that there are 125 million work-related accidents worldwide each year (Kirschenbaum, Oigenblick, and Goldberg, 2000). Despite the numerous recent epidemiological studies conducted on the causes of work related incidents, there has been limited progress in occupational injury prevention in the previous decade (Sorock and Courtney, 1997). This is further supported by US Department of Labor data that show there is a consistent volume of occupational injury in the United States, even though recent fluctuations in occupational injuries indicate a potential leveling in overall incidence rates (US Department of Labor, Bureau of Labor Statistics, 1995b). The purpose of this study was to develop a method to predict compliance with safety regulations, using key factors and personality traits that were predicted to affect individual safety behavior. The factors evaluated in this compliance model were: the employee's age, gender, history of injury, experience at that job task (tenure), task related risk perception, perception of the physical exertion associated with the present job function, and perception of management commitment to safety. Additionally, personality traits investigated were risk taking and anxiety. The results support that personality traits (specifically gender), and perceptions of management commitment to safety, influence the likelihood that an employee will comply with safety regulations. There are both theoretical and practical implications of the results of this study. In the following sections, the theoretical and practical implications of each significant result will be evaluated.

Effects on Compliance

The results of this study indicate that the gender of the employee and his or her perception of management commitment to safety had effects on safety compliance. Workers with higher perceptions of management commitment to safety had higher compliance with PPE regulations than those who had lower perceptions. This can be linked to a study by Fleming, Flin, Mearns and Gordon (1997) that correlated workers' risk perception with satisfaction with safety measures. Since high satisfaction with safety measures is a result of and thus an indication of management commitment to safety, leads to higher compliance.

From a practical perspective, this indicates that in order to achieve a high management commitment perception, management would have to demonstrate their support of and commitment to new and existing safety programs. When workers perceive that management has a strong commitment to safety, they may be more influenced by safety policies. In contrast, if a company's major focus is on productivity gains at the expense of safety, this may diminish the perceived commitment to safety programs, thus negatively affecting employees' compliance. This suggests that it would be beneficial for a company to regularly survey employees' perceptions of its commitment to safety. When indications of low perception are documented, corrective measures can be taken to reverse the effect. Also, a higher correlation may be associated with a longer history of safety program success. Perhaps due to the fact that the subject company had recently established a formal safety program, the true effect of these safety programs may be masked. The impact of safety programs on employees' perceptions may increase with time.

Gender was also found to be a factor of significance in this study. In general, females had higher compliance with PPE safety regulations than males. When implementing a safety program, it is important to consider the demographic characteristics of the group. For example, previous studies have shown gender to have an effect on injuries. A retrospective study by Rabi, Jamous, AbuDhaise, Alwash (1998) of fatal occupational injuries in Jordan determined that the risk of injuries increased with age as well as gender. The highest fatality rate was in workers aged 56 years and above and the majority of the fatalities were males, accounting for 98% of the total. The overall fatality rate in men was nine times greater than in women. Even though the relationship of those injuries to compliance was not measured in that study, by achieving higher compliance, the risk of injuries is likely to be reduced.

While it is not feasible, practical, or legal to hire based on, or biased by, gender, in order to achieve compliance, a workgroup consisting of a majority of males may require a more stringent safety program and a higher level of supervision in order to maintain compliance and a safe work environment.

Alternatively, this result might be attributable to the environmental requirements of the task. Since, females had more direct contact with chemical exposures, this exposure may have reinforced the need for compliance. On the other hand, males had more jobs that involved the use of machinery that had a greater variety of safety requirements with which to comply. This variety may have decreased compliance rather than the classification of gender itself. This is consistent with a study by Deguire and Messing (1995) addressed in a paper by Kirschenbaum, Oigenblick, and Goldberg (2000), where they attribute the high incidence of injuries among men

to their typically higher exposure to risky job activities than females. More research is necessary where variability in job tasks can be controlled.

Workplace Parameters that Affect Risk Perception

This investigation showed that workers who had higher perceptions of the physical exertion of their current job task had higher risk perception than those who had lower perceptions of exertion.

Borg (1998), claims that perception of exertion at very high intensities is connected with diminishing working capacity, but at low or moderate intensities, may be related to a state of activation, which has a positive effect on performance. Additionally, Dahlback (1991) stated that individuals who are bold (high-risk takers) have more injuries than those who are cautious. Therefore, to have a consistently low injury environment, emphasis needs to be placed on increasing the employees' awareness of the risks and hazards of their job, which may increase their risk perception of the task.

In support to Borg and Dalhback's statements, and the findings of the present study found, it was determined that this can be achieved in part through increasing the physical perception of job tasks. In practice, this could be used as a tool for job placement from an injury reduction perspective. Employees could be placed in jobs where their physical perceptions accurately reflect the risk of the job. Additionally, it could be used to direct training requirements to increase workers' knowledge of the risks involved in physical exertion.

Despite the fact that there was no significant correlation between perception of physical exertion and compliance, perception of exertion may still be a critical factor in evaluating

compliance behavior. Jobs that workers perceive as requiring very high physical exertion may cause workers to concentrate on the physical exertion requirements on the job, leaving less attention for safety compliance. The opposite effect on compliance may also be true. Employees who perceive that their jobs require very high physical exertion may be more concerned about their safety and thus focus more on compliance. This could explain why no direct effect of perceptions of physical exertion on compliance was found. The behavior of the two subpopulations may be counterbalanced.

Tenure was also related to risk perception. Workers with longer tenures in their current job task had lower risk perception than those who had shorter tenures. It seems that as workers remain in their jobs for longer periods without injury, they become inured to or less aware of the risk involved. In low attrition environments, a company might need to emphasize retraining to insure that workers remain cognizant and respectful of their job risk.

Relationships Among Workplace Parameters

This study also investigated the relationships among the workplace parameters (see Table 4, Page 37). Workers with higher tenure tended to be older than the average of the study population. Tenure was also related to history of injury, where workers who had been at their current task longer were more likely to have had a job-related injury. This might have been because employees who perform the same task for a long period of time become comfortable with the risks, thus obtaining a false sense of security. This can lead to short cuts that could ultimately place them at a higher risk of getting injured.

Perception of management commitment to safety was also found to decrease with

tenure. Those employees who had been longer in their current task had a lower perception of management commitment to safety than those with shorter tenure. This could be a result of past experiences of high tenured employees who previously had no exposure to formal safety programs. They may have built a low perception of management commitment to safety and were not convinced by the new focus on safety. The same result could take place in companies that have had a history of unsuccessful safety programs, thus creating a low perception of management commitment with higher tenured employees. Changing this perception may be more difficult than simply adding a new safety program.

On the other hand, the reverse may also be true. If a company maintains a consistent effort to support a visible safety culture, the effect on perceptions may be robust across many safety initiatives, even if some of them are not successful. Further research to evaluate this potential is necessary.

Older workers had lower perceptions of the physical exertion of the task than younger workers. This may be attributable to the fact that as older employees become more comfortable with the task they are performing, they fail to continuously assess the physical risks of their jobs.

Additionally, it was found that employees with a history of injury had a lower perception of management commitment to safety than those who did not have a history of injury. This is compatible with a recent study by Kirschenbaum, Oigenblick, and Goldberg (2000) who discovered that those employees with a frequent history of injury attributed it to a lack of safety conditions and management practices. It may be the case that once an employee becomes

injured, they may (justifiably or unjustifiably) fault management for their injury, thus lowering that employee's perception of management commitment to safety. This can become a downward cycle as workers who are injured reduce their perceptions of management commitment to safety, and thus are less likely to comply with safety rules, increasing their risk of additional injuries in the future.

Furthermore, this study showed that gender was associated with employees' anxiety levels and risk taking behavior. Males were found to have higher levels of anxiety than females, and females had stronger risk-taking personalities. Though this runs contrary to population averages, it is likely that females who choose to work in manufacturing environments are self-selected subpopulations that may not be representative of the population as a whole. In a manufacturing environment where females comprise a high percentage of the population, caution must be taken since a higher risk exposure to injuries may exist.

From a theoretical perspective, we can better understand the attitudes and behaviors of workers towards safety from these results. Each worker's behavior will be motivated by a complex set of inputs ranging from internal factors such as personality and gender to external factors such as management and coworker practices. These results indicate that gender and perceptions of management commitment to safety are two of the factors that directly affect compliance. Other factors may also play a role. For example, workers who had been working at the same job for an extended time tended to have reduced risk perception, and increased perceptions of physical exertion also led to greater risk perception. These relationships may lead to changes in compliance that the current study was not sensitive enough to measure.

These two parameters' effects on risk perception illustrate how the complexity of the work environment can affect behavior. There are many possible explanations for these relationships. Perhaps when a worker is concentrating on the physical difficulty of a task, he/she has less attention left over to consider safety practices. Extended tenure may cause a worker to complete his/her tasks automatically, with less attention to perceptual information that may indicate an unsafe condition. A better understanding of these cognitive and perceptual processes would lead to improved safety management.

Departmental Differences

It is important to note that departmental differences were found in the results of variances for the variables of tenure, perception of physical exertion, age, anxiety, and compliance. This may be due because each department has job tasks that require different levels of physical exertion. Thus this may explain the differences of these variables within departments. These differences in Job task requirements per department may also have an affect in the difference between anxiety levels between the groups. Also, variances in tenure and age may be due to high turn over rates in some departments versus others.

The Compliance Model

In this study, a model to describe the relationships between several workplace and demographic parameters and safety compliance were investigated. Further analysis was conducted to determine which of these parameters directly affect compliance and which are moderated by risk perception. This comparison was made for practical considerations. Interventions for any parameters that are moderated by risk perception can be tailored to the

risk perception aspect, but those that are not must be the target of intervention individually, which can be more expensive and harder to implement effectively.

It was found that compliance was affected by gender and perception of management commitment to safety. These two factors are important and warrant close attention in the study of behavioral safety compliance. They can be used to predict compliance and to target interventions that improve compliance. Conversely, the other parameters did not have a significant affect on compliance. Whether this is related to limitations of the specific data collection environment or a general lack of importance of these other parameters remains unknown.

Introducing the risk perception variable did not provide a significant improvement to the model. In the environment studied, prediction of compliance cannot be improved by measuring risk perception. There are several possible explanations for this finding. It may be that no parameters are moderated by risk perception and all of them must be individually targeted in intervention efforts. It may also be that lack of any history of safety programs at the company in which the data was collected masked the effects of risk perception.

Before this model is implemented in industry, further development is necessary. However, this initial step has illustrated many of the components that must be investigated to create a practical model to predict safety compliance and to target interventions as part of a general safety program.

Limitations

This is a study where the data collected is derived from one manufacturing company only. In this company, the population is 90% comprised of employees of Hispanic origin. This may introduce some inherent employee cultural values into the survey results. Additionally, 80% of the workforce consisted of blue-collar employees in non-automated manufacturing tasks. Furthermore, at the time of the study, the company was experiencing financial challenges that affected management expenditures on safety, and management's follow-through on their commitment. These factors could affect the employee's perception of management commitment to safety. The company has a high attrition rate, which resulted in employees with relatively low tenure. Finally, the company had a prior history of poor safety practices, which may have forged a low perception regardless of the current practices.

Suggestions for Future Research

In this study, several factors were investigated to determine their effect on compliance directly or as moderated by risk perception. This distinction can be critical for practical intervention to improve safety compliance. Further study of these factors should be conducted in a variety of work environments to determine which ones have significant effects on compliance and under what conditions.

Furthermore, this study showed that as tenure increased, risk perception of the task decreased, perception of management commitment to safety decreased, and history of injuries increased. Understanding this progression may be very important in reducing the incidence of injuries. Several interventions, such as provision for retraining to target improving risk

perception, and perceptions of management commitment to safety, may be helpful and should be investigated further.

While a variety of past research has been focused on leading causes and contributing factors to work related injuries, intervening earlier, at the point of compliance, would be much more effective at reducing injuries. Studies have shown that early interventions are much more effective, in that they increase compliance. Unsafe behavior that does not lead to an injury can increase future risk taking behavior among the entire workforce. Increasing compliance is a critical objective in its own right. Therefore, further investigation in this area would be highly desirable to industries.

VII. CONCLUSION

Developing methods to evaluate and predict safety behavior is of importance in maintaining and addressing a safe work environment, preventing accidents, ensuring compliance, and reducing associated costs. The present study focused on developing a model to predict safety compliance. This model found two variables that had a significant influence on safety behavior. It may be possible to expand and customize this model to provide a reliable predictor of safety compliance by evaluating companies' unique population characteristics and the perceptions of its workers.

TABLES & FIGURES

Table 1

General Departmental Tasks

A general description of each the departmental operations are described below.

Department	Task Description
Finishing:	Artistic manual application of paints through spraying and hand decorating processes.
Metal Preparation:	Preparation and cleaning of metal components prior to spraying on a base coating.
Pre Assembly:	Pre-determination of the first stage of assembly and wiring of lighting fixtures and accessories.
Shades decoration:	Decoration of previously assembled fabric shades to be shipped with lighting products.

Table 2

Summary of Job Tenure for Each Department.

Departments	Function	Number of Employees	Tenure [Avg. Yrs. in Job]	Avg. Age
Finishing	Decorating/Leafing,Spraying Material Handling Mixing and distribution	101	3 yrs	41 yrs
Metal Preparation	Spraying Material Handling Metal cleaning	10	6 yrs	46 yrs
Pre Assembly	Assembling/Wiring Material Handling	6	3 yrs	50 yrs
Shades decoration	Decorating	8	4 yrs	52 yrs

Table 3

PPE Equipment Specifications

REF. #	PPE	DEPT.	TASK	SPECIFICATION
		HAND PROTECTION		
1.0	GLOVES # 83 (ASTRO FLEX LATEX). Natural Rubber.	FINISHING	Decorating Shade Deco Spraying Mixing and Distribution	Exhibit long lasting tensile strength and maximum touch sensitivity. Resists abrasion, punctures and tears. Provides resistance to a broad group of chemicals.
2.0	TOUCH N TUFF NITRILE (GREEN) GLOVES	FINISHING SHADE DECORATION	Decorating Shade Deco Leafing	Synthetic rubber that is resistant to solvents, oils, greases, acids, caustics petroleum, punctures, cuts, snags, and abrasions. **Note:** The glove gauge will affect the permeability and resistance to chemical and physical hazards. The thicker the Nitrile glove, the greater its resistance to chemicals, but the lower its flexibility.
3.0	LEATHER WORK GLOVE	FINISHING METAL PREP	Material Handlers	Strong dense fibers withstands abrasions/ scrapes. Provides protection for handling sharp objects and general material handling.
		EYE / FACE PROTECTION		
4.0	ENCON EYE GLASSES #1910 TOUGH SPEC ANTI-FOG	FINISHING PRE-ASSEMBLY METAL PREP SHADE	Finishers Shade Deco Spraying Mixing and Distribution Assembling Metal Preparation	Polycarbonated lightweight, and impact resistant with side shields. Outer barriers resists scratches and impact. Protects against corrosive and harmful chemicals for long wear in chemical splash situations.

Table 3 (Continues)

PPE Equipment Specifications

REF. #	PPE	DEPT.	TASK	SPECIFICATION
		BODY PROTECTION		
5.0	POLY APRONS 1.75 MIL 28X45 WHT #SCOAPCE255	METAL PREP	Metal Preparation	Coated with polyethylene film that repels moisture and provides protection against acids, oils, cutting fluids and other liquid chemicals.
6.0	TYVEK APRONS 24X36 PAPER	FINISHING METAL PREP	Finishing Shade Deco Spraying Mixing and Distribution Assembling Metal Preparation	Non-woven material. Tear resistant material that provides protection against chemical splash and other hazardous materials.
		RESPIRATORY PROTECTION		
7.0	HI-FILTRATION ISOLATION MASK #19101M (Particulate respirator/mask)	FINISHING	Leafing	Lightweight construction for comfort and increased wear time. Use where particulate dust is below the PEL.
8.0	RESPIRATOR 3M 5301 (5000 series)	FINISHING METAL PREP	Sprayers Mixing and Distribution Metal Prep	Organic vapor respirator with 5N11 N95 Particulate prefilters.
		BACK PROTECTION		
9.0	BACK SUPPORT BELT # BSDC9	FINISHING PRE- ASSEMBLY METAL PREP SHADE DECO	Finishing Shade Deco Spraying Mixing and Distribution Assembling Metal Prep. Material Handling Assembly	

Table 4

Anxiety as Described by JPI-R

Scale	Description of High Scorer	Defining Trait Adjectives of High Scorer	Description of Low Scorer	Defining Trait Adjectives of Low Scorer
Anxiety	Trends to worry over inconsequential matters; more easily upset than the average person; apprehensive about the future.	Worried, tense, nervous, preoccupied, anxious, edgy, distressed, agitated, fearful.	Remains calm in stressful situations; takes things as they come without worrying; can relax in difficult situations; usually composed and collected.	Easy going, patient, calm, serene, tranquil, relaxed, contented, placid, imperturbable.

Table 5

Risk Taking as Described by JPI-R

Scale	Description of High Scorer	Defining Trait Adjectives of High Scorer	Description of Low Scorer	Defining Trait Adjectives of Low Scorer
Risk Taking	Enjoys gambling and taking a chance; willingly exposes self to situations with uncertain out comes; enjoys adventures having an element of peril; takes chances; unconcerned with danger.	Reckless, old, impetuous, intrepid, enterprising, incautious, venturesome, daring, rash.	Cautions about unpredictable situations; unlikely to bet; avoids situations of personal risk, even those with great rewards; doesn't take chances regardless whether the risks are physical, social, monetary or ethical.	Cautions, hesitant, careful, wary, prudent, discreet, heedful, unadventurous, precautionary, security-minded, conservative.

Table 6

Descriptive Statistics

		Mean	SD	Range (Min-Max)	1	2	3	4	5
1	Average Compliance	76.54%	18.30%	24% 100%	-				
2	Risk Perception	3.31	1.13	1.00 5.00	-.013	-			
3	Work experience	3.46	3.32	0.22 21.63	.001	-.214*	-		
4	Age	42.90	11.09	21.28 78.13	-.014	-.168	.343**	-	
5	History of injuries	.33	.47	0.00 1.00	-.105	-.042	.297**	.066	-
6	Perception of physical exertion of the task	5.90	2.66	1.00 12.00	.086	.303**	.018	-.218*	.015
7	Perception of management commitment to safety	3.96	1.12	1.00 5.00	.272 **	.092	-.192*	-.057	-.249**
8	Gender	N/A	N/A	N/A	-.197 *	-.156	.078	-.059	.162
9	JPI Anxiety Std. Scores	44.06	7.40	25.00 63.00	-.047	-.162	.092	-.036	.036
10	JPI Risk Taking Std. Scores	57.78	7.27	37.00 76.00	.094	.139	.019	.011	-.042

(Table continues)

Table 6 (Continued)

Descriptive Statistics

		6	7	8	9	10
6	Perception of physical exertion of the task	-				
7	Perception of management commitment to safety	.012	-			
8	Gender	.042	-.054	-		
9	JPI Anxiety Std. Scores	-.016	.133	.451**	-	
10	JPI Risk Taking Std. Scores	.065	.049	-.440**	.196*	-

*p<.05 ; **p<.01

Table 7

T-Test Results: Mean and Standard Deviations of Variables Correlated With Gender

	Gender	Mean	Standard Deviation	t
JPI Anxiety Std. Scores	Female	42.40	6.80	-5.6**
	Male	50.72	5.87	
JPI Risk Taking Std. Scores	Female	59.37	6.52	5.44**
	Male	51.40	6.67	
Average Compliance	Female	78.34%	16.63%	2.23*
	Male	69.36%	22.86%	

*p<.05 ; **p<.01

Table 8

T-Test Results: Mean and Standard Deviations of Variables Correlated With History of Injuries

	History of Injuries	Mean	Standard Deviation	t
Work Experience	No	2.77	2.77	-3.4**
	Yes	4.86	3.88	
Perception of Management Commitment to Safety	No	4.15	1.07	2.9**
	Yes	3.56	1.14	

*p<.05 ; **p<.01

Table 9

Multiple Comparisons and Means Results for Variables Significant at the .01 Level.

	Departments	**Means**	**Mean Difference**
Tenure	Metal Preparation and Finishing	6.5 / 3.1	3.5
Perception of Physical Exertion of the Task	Pre-Assembly and Shades	7.2 / 2.9	4.3
	Shades and Finishing	2.9 / 6.2	3.3
Age	Shades and Finishing	54.5 / 41.0	13.4
JPI Anxiety Std. Scores	Metal Preparation and Finishing	51.4 / 43.5	7.9
Average Compliance	Finishing and Shades	79.1 / 57.0	22.1

Table 10

Multiple Regression to Test the Effects of the Independent Variables on Compliance.

Steps	Variable	R^2	df	ANOVA		Std	
				F	Sig.	Beta	Sig.
DV	Compliance						
1	Gender	.12	124	2.0	.052	-.197	ns
	Percp of mgmt commitment to safety					.268	.005**
	Percp of Physical Exertion of the task					.088	ns
	Tenure					.080	ns
	History of Injuries					-.031	ns
	Age					-.016	ns
	Risk Taking					-.015	ns
	Anxiety					.004	ns

*p<.05 ; **p<.01
ns: Not Significant
N=125

Table 11

Hierarchical Regression Analysis for Variables Predicting Compliance. Moderating Effects of Risk Perception.

Steps	Variable	R^2	R^2chg	Fchg	df 1	df 2	Sig. F chg	ANOVA F	ANOVA Sig.
DV	Compliance								
1	Gender Percp of mgmt commitment to safety Percp of Physical Exertion of the task Tenure History of Injuries Age	.12	.12	2.7	6	118	.02*	2.7	.02*
2	Risk Perception	.13	.01	1.0	1	117	.31	2.5	.02*
3	Risk Perception x Percp of mgmt commitment to safety Risk Perception x Tenure Risk Perception x History of Injuries Risk Perception x Percp of Physical Exertion of the task Risk Perception x Gender Risk Perception x Age Risk Perception x Risk Taking Risk Perception x Anxiety	.14	.01	.34	4	113	.85	1.7	.09

*p<.05 ; **p<.01
N=125

Figure 3

Correlation of Worker's Perception of Management Commitment to Safety Versus Compliance. Where the Compliance Score is the Number of Observations in Which Compliance was 100%.

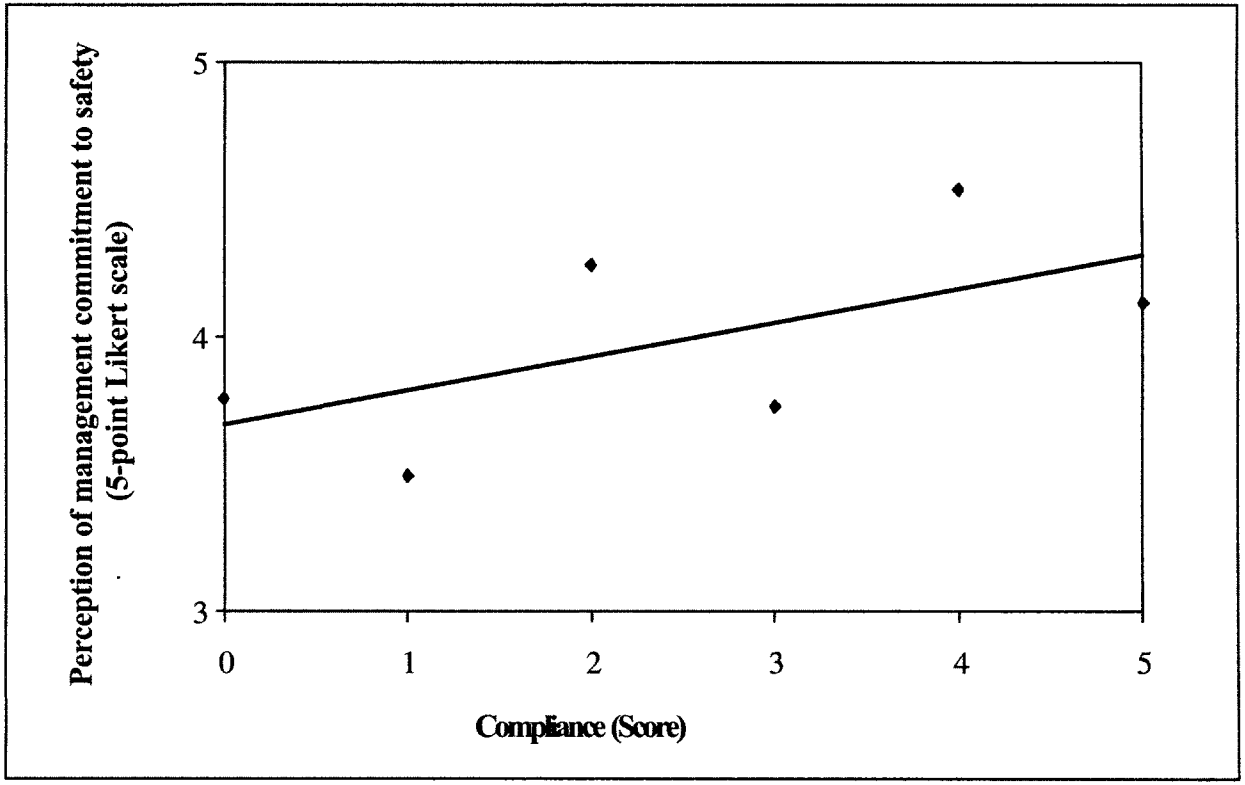


Figure 4

Distribution of the Average Compliance Scores for Male and Female Workers.

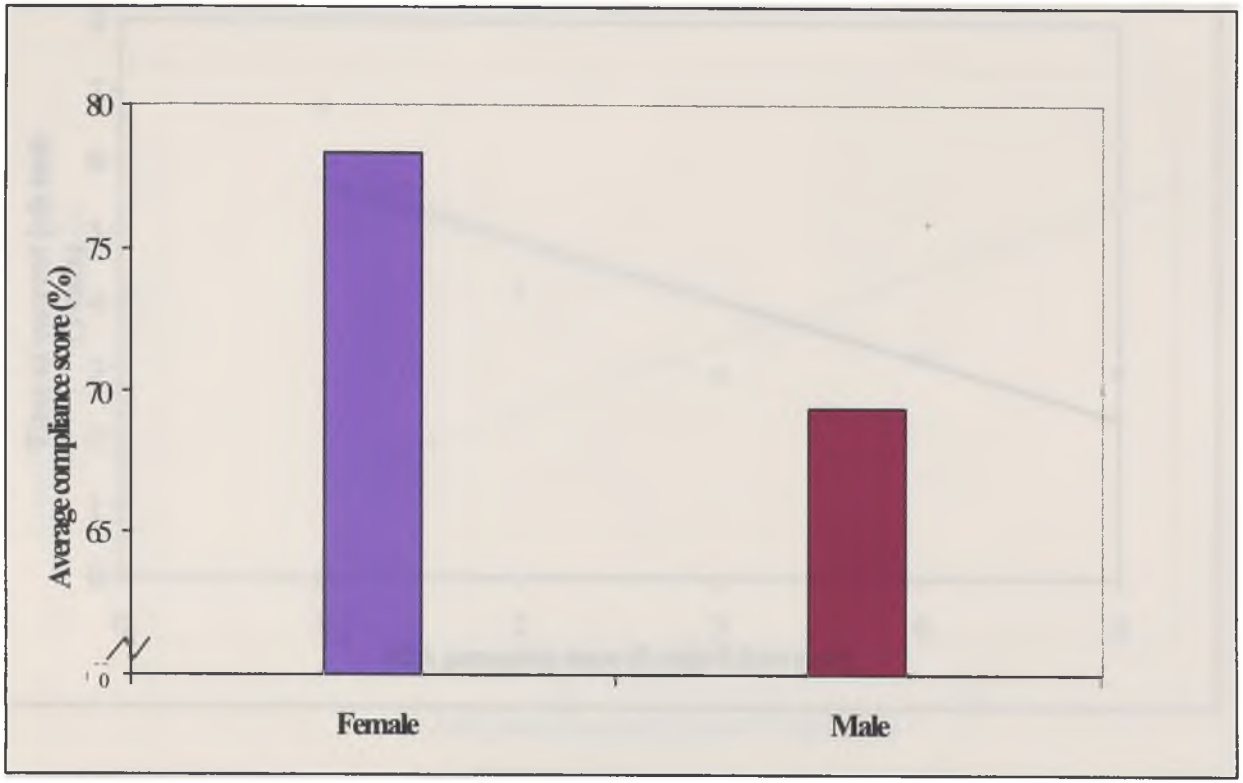


Figure 5

Correlation of the Worker's Number of Years at the Current Job Task Versus their Perception of Risk.

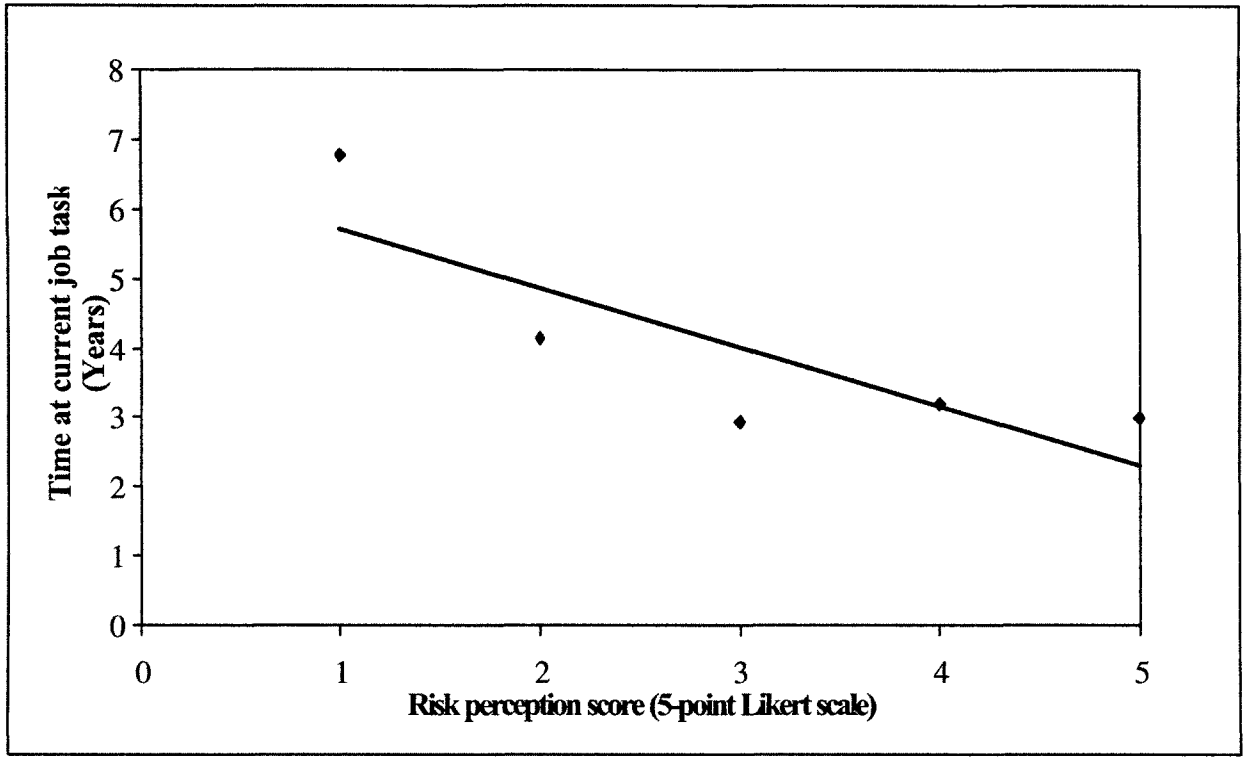


Figure 6

Correlation of the Worker's Perception of Physical Exertion of the Task Versus Risk Perception.

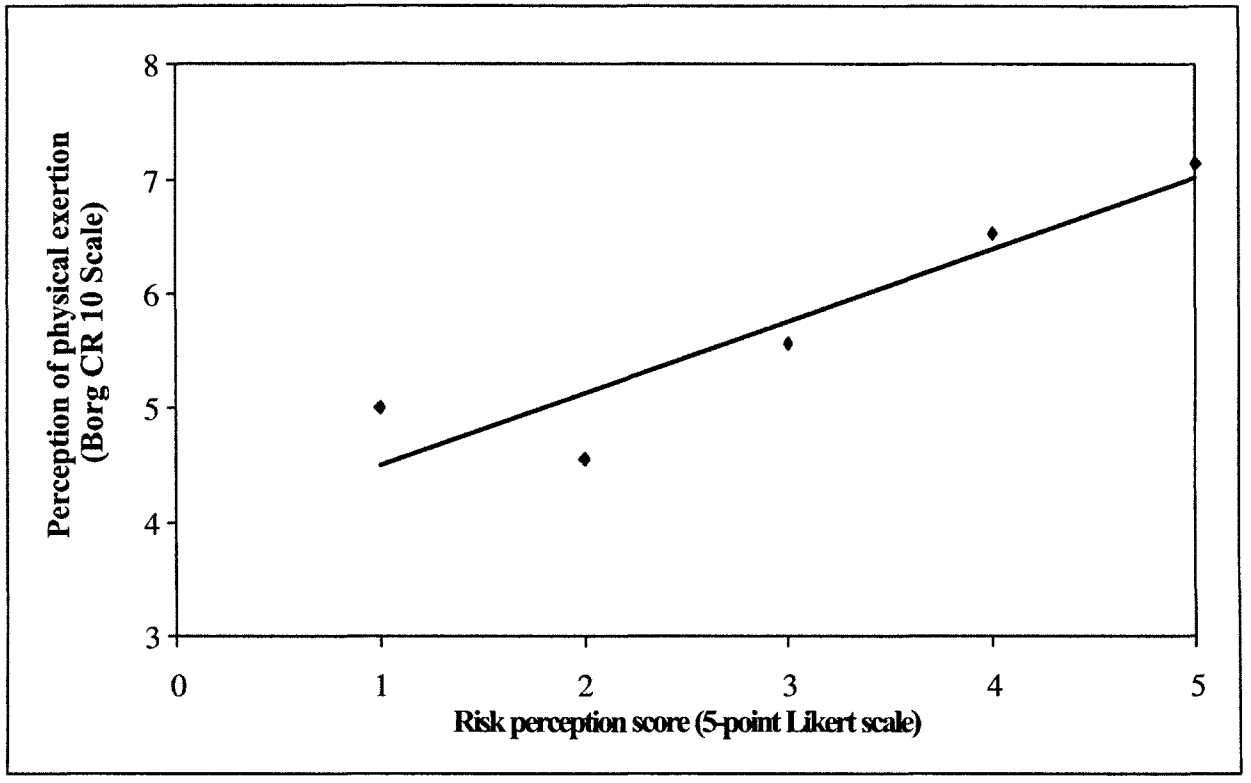


Figure 7

Correlation of Worker's Perception of Management Commitment to Safety Versus their Tenure at the Current Job Task.

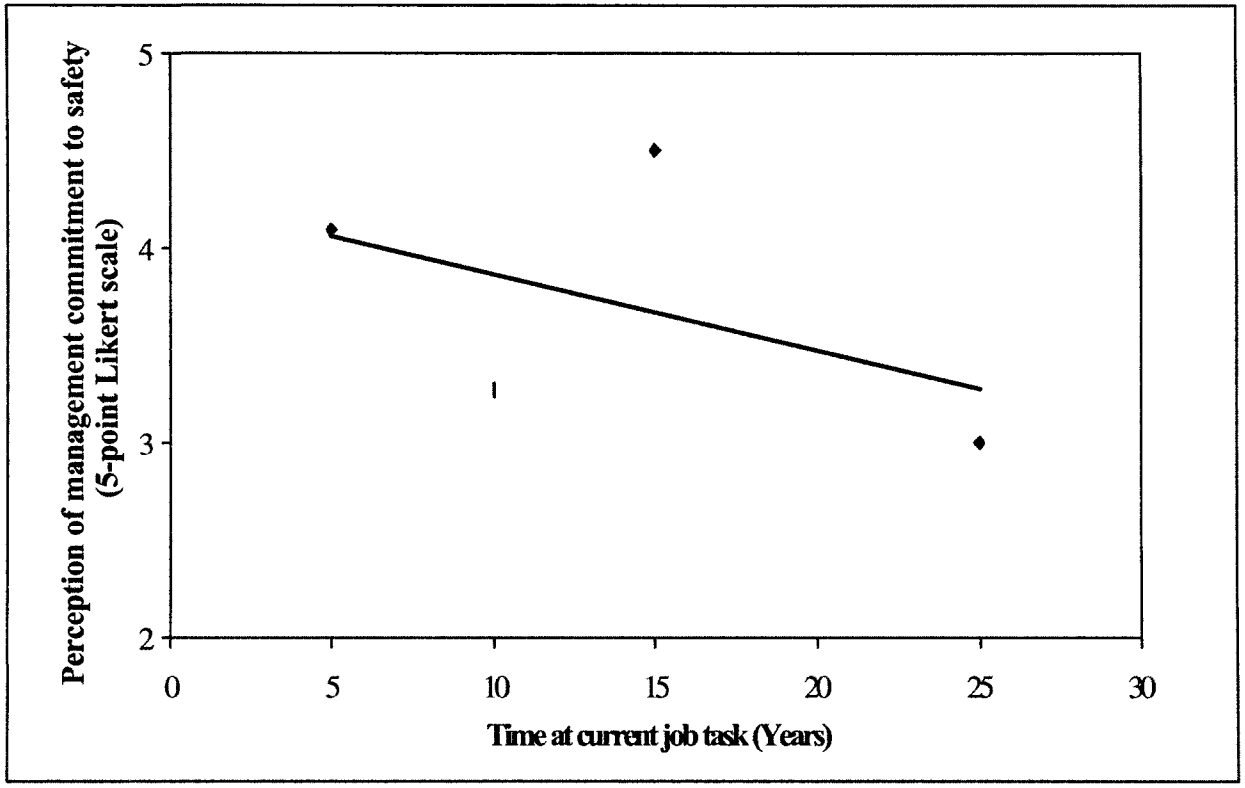


Figure 8

Correlation of Worker's Perception of Physical Exertion of the Task Versus Age.

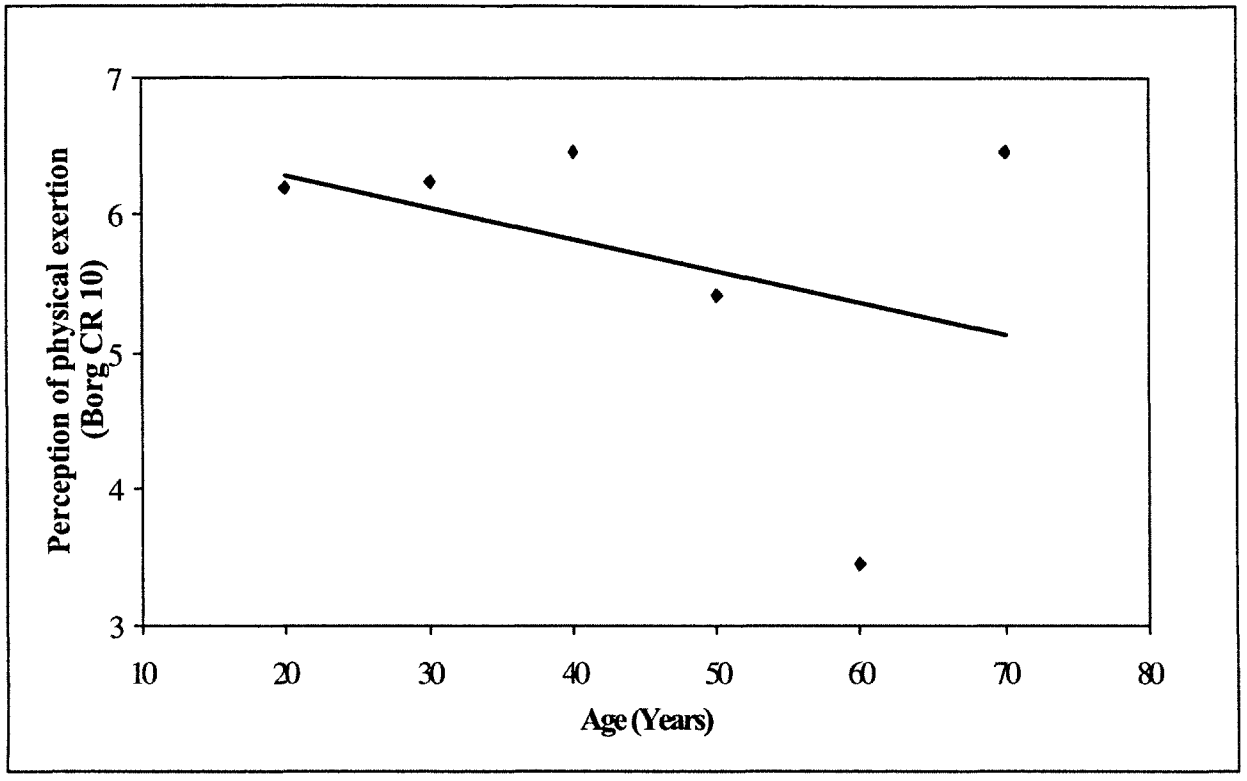


Figure 9

Worker's Perception of Management Commitment to Safety Versus their Recorded History of Injuries.

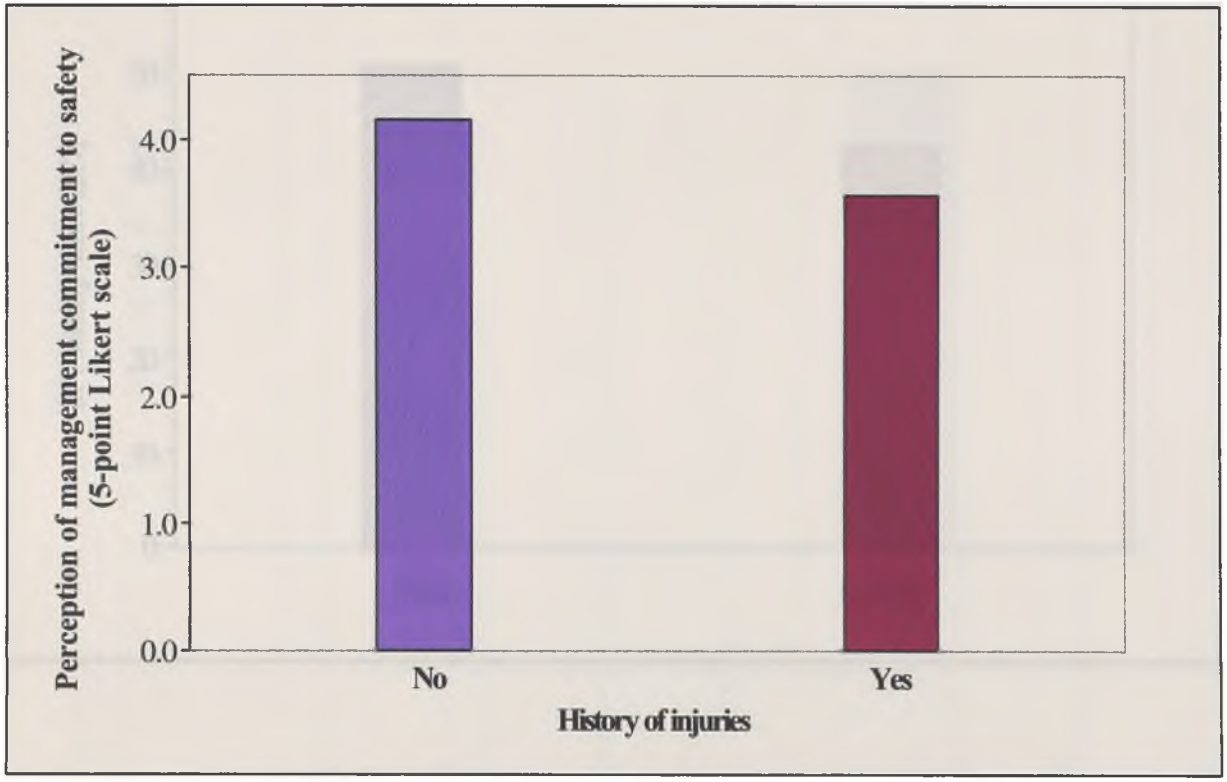


Figure 10

JPI Anxiety Scores for Male and Female Workers.

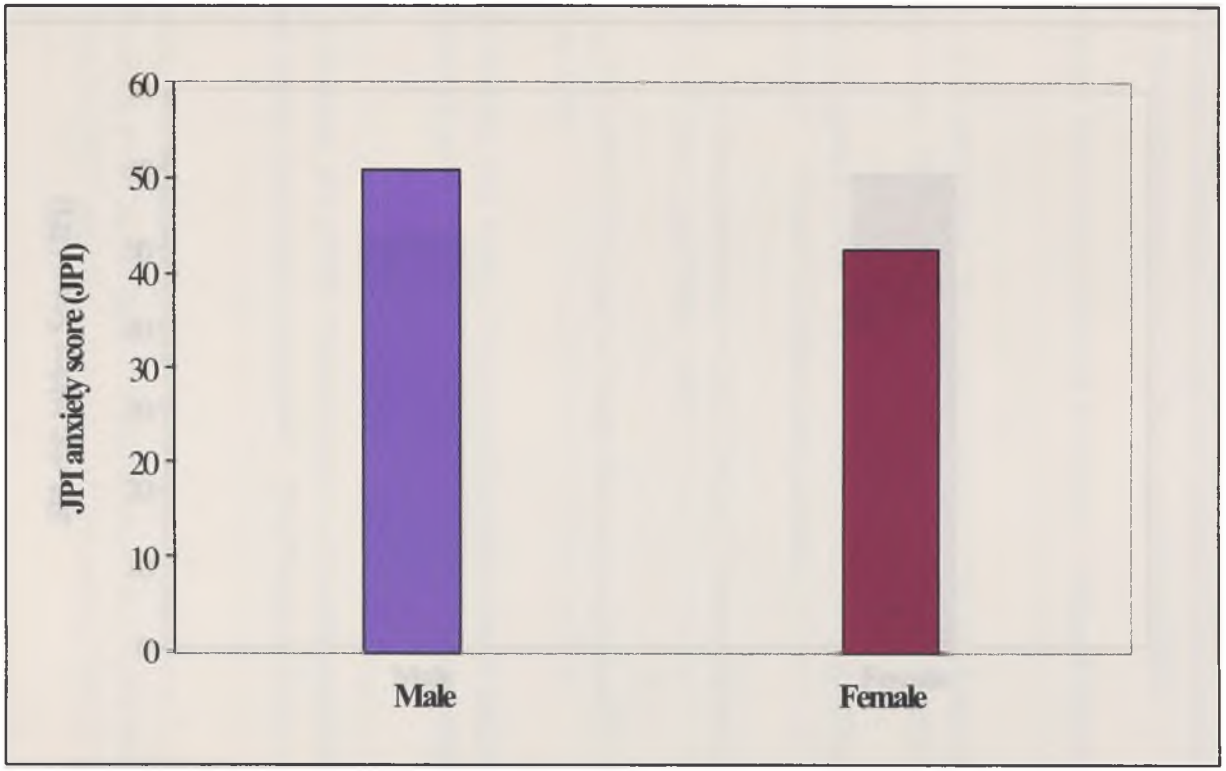
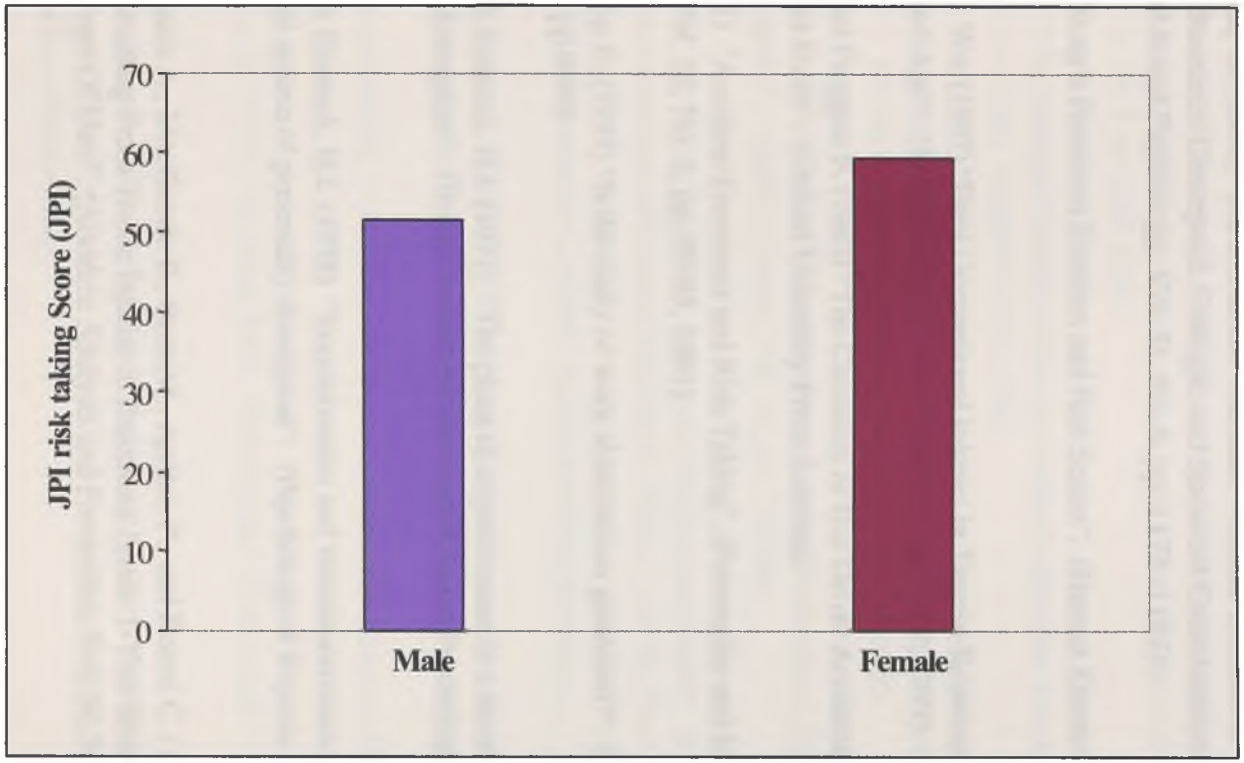


Figure 11

JPI Risk Taking Scores for Male and Female Workers.



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Appendix A

Survey

Name: _____ Age: _____

Position:_____ Gender: ____Female ____Male

Department: _____

Have you ever been injured at work:

___Yes, No ___

(Refers to recordable injuries, which required medical treatment or resulted in lost time).

How long have you been performing the present task. List the number of years or hire date:

_____ Number of Years or Date of Hire _____

Please rate the physical exertion required by your job:

(Please circle the corresponding number)

0 – Nothing at all
1 – Very weak
2 - Light
3 – Moderate
4 –
5 – Heavy
6 –
7 – Very strong
8 –
9 –
10 – Extremely strong
11 –
• Highest possible

Appendix A (Continues)

Survey

Please rate how committed you believe the management of this company is to your safety: Circle the corresponding number to your answer. (Low commitment) 1-------2------3------4-------5-------6 (High Commitment)

Please rate of how much risk to your personal health and safety is there in your job: Circle the corresponding number to your answer. (Low risk) 1-------2------3------4-------5-------6 (High Risk)

Appendix B

Photos Depicting Specified PPE

SAFETY GLASSES

DUST MASK

LATEX YELLOW GLOVE

NITRILE GLOVE

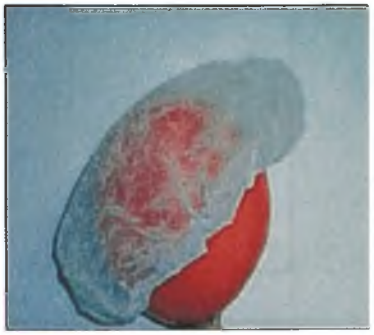
RESPIRATOR

NITRILE HEAVY GLOVE: ALTERNATIVE FOR REGULAR LATEX YELLOWGLOVE

HEAVY DUTY GLOVES

BACK SUPPORT BELT

TYVEK APRON



HAIR NET (OPTIONAL USE). NOT CONSIDERED FOR COMPLIANCE MEASURES.

Appendix C

Photos Illustrating Sample PPE Use.

Decorators/Leafers: (Masks limited to leafers only)
Belts, Apron, Nitrile gloves, Dust mask, Safety glasses

Sprayers:
Belts, Apron, Nitrile gloves, Respirators, Safety glasses

Material handlers:

Belts, Heavy duty gloves

Assemblers:

Safety glasses, Belts