4-8-2003

An Analysis of Workplace Amputation Injuries in Florida

Eve N. Hanna M.D.
University of South Florida

AN ANALYSIS OF WORKPLACE AMPUTATION INJURIES IN FLORIDA

by

EVE N. HANNA, M.D.

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Public Health
Department of Environmental and Occupational Health
College of Public Health
University of South Florida

Major Professor: Stuart M. Brooks, M.D.
Matthew A. Vuskovich, M.D.
Phillip P. Roets, Sc.D.

Date of Approval:
April 8, 2003

Keywords: safety training, prevention, occupational, industrial hazards, machine safety

Acknowledgments

I would like to acknowledge everyone at the USF Safety Florida Consultation Program for their technical support and expertise as well as their encouragement. Without this group, I would not have been able to undertake this project. I would also like to thank Tom Berish for his time and assistance with the behavior-based safety portion of my thesis. Finally, I would like to say a word of appreciation for the guidance and vision from Dr. Brooks.

Table of Contents

List of Tables

List of Figures

An Analysis of Workplace
Amputation Injuries in Florida

Eve N. Hanna, M.D.

ABSTRACT

Nationally, 10,852 workplace amputation injuries in the US were reported in1997. This number has been gradually decreasing over time to 9,658 amputations in 2000. In Florida, the amputation injuries have been increasing from 272 in 1997 to 417 in 2000. The reason for this increase is unclear and deserves further study. The purpose of a portion of this study was to examine the Federal and Florida BLS data to determine the characteristics of the typical worker with an amputation injury. A worker with an amputation injury was most likely to be a white male between the ages of 35 and 44 with 1 to 5 years of employment. The amputated part was usually a finger which was injured in a machinery source. The purpose of the self-designed survey was to determine if there were any differences in the amputation prevention strategies between companies with and without amputation injuries. The survey also attempted to uncover any changes made to the safety training program after an amputation injury occurred. Using the Florida workers compensation data, surveys were sent to all companies with amputation injuries for the years 1999, 2000, and 2001. An equal number of surveys were sent to companies without amputation injuries during the same years of interest. A total of 840 surveys were mailed out. 146 were returned as undeliverable. 35 surveys were returned in the amputation group and 35 surveys were returned in the control group. All SIC codes were

represented except mining. In the amputation group during the years investigated, 15 out of 35 (42.9%) companies claimed amputation injuries and 20 (57%) companies did not. The true error rate for the workers compensation data was a 13% misclassification of amputation injuries into that category. Comparison of the prevention strategies between the amputation and control groups revealed no significant differences. Of the companies claiming amputation injuries, 8 out of 15 (53%) made no changes to their safety training program after the injury occurred. Proactive techniques and global changes in safety culture mindset will be necessary before major reductions in amputation injuries can occur.

Introduction

Amputations in the workplace are preventable yet persistent occupational injuries. The majority of workplace amputations involve one or more fingers. Although this loss may not seem serious, finger dexterity is a crucial factor for many jobs. The Federal Bureau of Labor Statistics reported 10,852 workplace amputations in the US in 1997.[1] This number has been gradually decreasing over time to 9,658 amputations in 2000. In Florida, the amputation numbers have been increasing from 272 in 1997 to 417 in 2000.[2] The reason for this increase is unclear and deserves further investigation. Despite the continuing awareness of this injury, little is known about amputation risk factors, or the underlying causes. Before effective prevention strategies can be implemented, these basic factors should be identified.

Injury prevention strategies in the workplace always include hazard analysis, training, engineering controls, administrative controls, and as a last resort, PPE. It is well known that 90% of accidents are caused by unsafe behaviors and only 10% are caused by unsafe conditions. It would make sense to emphasize a behavioral based type of prevention program. A new approach to safety based on behavior techniques has been developed and implemented around the country beginning at Proctor and Gamble in the mid 1970s. This proactive program identifies critical safety related behaviors, develops preventive actions, measures compliance through observation, and provides feedback for improvement on an ongoing basis.[3] The prevalence of this technique in Florida is not known and should be uncovered.

In 1990, NIOSH felt that industry would be interested in the frequency and severity of machine-related injuries resulting in amputations and fatalities. The article, Machine Safety Research at NIOSH and the Future Directions led to research priorities toward alleviating problems of manufacturing machine-related injuries and fatalities.[4] These conclusions were the basis for the OSHA National Emphasis Program on Amputations.[5] Initially, a National Emphasis Program on mechanical power presses was established and implemented in 1997. This program was expanded in 1999 and was updated in 2000 and renamed the National Emphasis Program on Amputations. Major changes included the addition of all types of power presses, press brakes, saws, shears, and slicers as well as the original mechanical power presses. The purpose of the program is to identify and reduce workplace machine hazards which are likely to cause amputations. It includes three activities which are outreach, targeting and selection, and inspection. OSHA believes that the failure to guard machinery is a primary cause of amputations. This program will target industries with recorded amputation injuries and violations of 29 CFR 1910.212 (all machines), 1910.213 (woodworking machinery), and 1910.217 (power presses) for inspections. Although this approach will pinpoint high risk industries with amputation injuries, it still does not address the specific behaviors that lead to unsafe working conditions and the potential for future amputations.

Study Purpose

The purpose of this study is to delineate the prevention strategies used by companies to prevent amputation injuries.

Research Objectives

1. To delineate the demographic and nature of injury data for workers with amputation injuries in the US and Florida and to compare the two groups.
2. To uncover the prevention strategies used by companies to prevent amputations.
3. To determine if there are any differences in prevention strategies between companies that had amputation injuries and companies who did not.
4. To discover if any changes were made in the safety training program after a company had an amputation injury.
5. To define the percentage of companies using behavior based safety training as their prevention strategy or as their post-amputation safety program change.

Thesis Hypothesis

There will be no difference in the prevention strategies used by companies with amputation injuries and companies without amputation injuries.

Literature Review

The National Electronic Injury Surveillance System (NEISS), funded by NIOSH, reported on the nonfatal occupation injuries and illnesses treated in hospital emergency departments in the US.[6] For the year 1998, 27% of the injuries were lacerations, puncture wounds, avulsions, or amputations. Hands and fingers were the most commonly injured body parts. Amputations were not discussed separately. Younger workers had the highest rates of work-related injuries and illnesses. The NIOSH publication, Injuries and Amputations Resulting from Work with Mechanical Power Presses, emphasized the amputation hazards of these machines.[7] Their research indicated that 10% of amputations have occurred among power press operators. Statistics gathered by OSHA indicated that about 50% of the injuries from mechanical power presses resulted in amputations. NIOSH found that young male operators appeared to be at the greatest risk for injury. They developed recommendations for the safe use of mechanical power presses especially those operated by foot or dual palm-button controls.

On the state level, Minnesota has investigated work-related amputations in the state and several articles are available on this topic. Minnesota is the only state with a surveillance program for work-related amputation injuries. This state has the Minnesota Sentinel Event Notification System for Occupational Risks (SENSOR) program funded by NIOSH which has collected data on work-related amputation injuries since 1992. One of their studies looked into the medical, personal, and occupational outcomes for 601 amputation injuries.[8] 66% reported that their amputation injury had adversely affected their participation in sports, hobbies, yard work, house work and other activities. The article on the Nature, Incidence, and Cause of Work-related Amputations in Minnesota revealed that most of the amputations happened to young males with little advanced education.[9] Over half of the finger amputations were to the dominant hand. About three-fourths of these injuries were associated with machinery. In many cases, the required safety devices for the machines were either not functioning properly or removed to do a specific job task. Michigan developed a five year strategic plan for reducing amputations in their state.[10] They plan to reduce amputation injuries by 15% in 2003. They identified high-hazard activities and high risk industries. Then they provided consultations for industries in the form of hazard surveys and evaluation of Safety and Health programs. They coordinated state-wide seminars and developed guidelines. Part of their strategy involved enforcement with focused and comprehensive inspections. 425 inspections yielded 4702 violations. It will be interesting to see how this intensive and focused approach worked to decrease amputation injuries at the end of this year. No articles relating to workplace amputations were found for the state of Florida.

OSHA published the bulletin, Safeguarding Equipment and Protecting Workers from Amputations as a prevention strategy in this high risk group.[11] The publication discussed how to recognize amputation hazards and how to safeguard against these hazards. It identified hazards and controls for specific types of machinery such as mechanical power presses, power press brakes, conveyors, printing presses, roll-forming and roll-bending machines, shearing machines, food slicers, meat grinders, meat-cutting band saws, drill presses, milling machines, grinding machines, and slitters. OSHA also developed a Fact Sheet on Amputations.[12] It pointed out the sources of amputation injuries in the workplace. It discussed the types of machine components and kinds of mechanical motions that are hazardous. It recommended safe work practices, employee training and administrative controls to help prevent and control amputation hazards. It also suggested that machine safeguarding with guards or devices was the best way to control amputations caused by stationary machinery. These publications delineated the most effective prevention strategies for decreasing amputation injuries in high risk situations relating to machinery.

Education for Job Safety and Health was a provocative article which tied together the importance of engineering controls with worker behavior in preventing injury and illness using job safety and health training.[13] Behavioral approaches to the prevention and control of work hazards need to be thought of as complementing engineering and personal protective device (PPD) controls. Education and training programs must teach the worker to avoid behaviors that might reduce the effectiveness of existing engineering controls and PPDs. The worker must be taught to use existing engineering controls and PPDs to his advantage to enhance their effectiveness. The worker must be taught to engage in work practices and personal health practices which reduce contact with hazards and limit opportunities for illness and injury. The article gave examples of the success of this behavior-engineering approach in preventing injury and illness in the workplace.

The article, Health and Safety Training in a Sample of Open-shop Construction Companies, tried to compare safety outcomes such as accident rates between companies with safety and health training and those without it but were unable to due so because of the small sample size.[14] The authors felt that observation of on-the-job performance was probably the most objective method for evaluating training effectiveness. Most of the companies surveyed had safety and health training programs but spent little time assessing the quality or effectiveness of training in terms of actual knowledge gain or skills enhancement. The study recommended that methods be developed to objectively quantify if the safety and health training increased productivity, work quality, morale, and job satisfaction.

The descriptive study, Mechanical Equipment Injuries in Small Manufacturing Businesses: Knowledge, Behavioral, and Management Issues did not specifically address amputation injuries but it made several important points about the factors that impact on the high rate of injuries due to mechanical equipment.[15] Eighteen percent of the employees from these small businesses commented during the interview process that their managers were not aware of the potential dangers of the workplace machinery. However, the managers all stated that they were aware of the hazards resulting in a perception difference. Half of the mangers had never received any safety training and 22% of the employees had not received any training either. Language barriers were mentioned as an issue that may have contributed to safety problems. Employers that were aware of workplace hazards felt they could be managed by having well-trained competent staff who followed good work practices. The hazards were not seen as a problem that needed to be fixed. In these small businesses, only half had specific safety regulations and the enforcement of these regulations did not always occur when they existed. None of the companies interviewed analyzed the injuries to determine priorities for injury prevention. Although 83% of the managers knew that safety management was their responsibility, only 66% of the workers felt that the managers took responsibility for this area. The article suggested that enforcement, education, and training could improve the injury rate from mechanical equipment in these small businesses.

Anthony Bimonte from DuPont Company in his article, Win Empowered Workers' Commitment to Exceeding Basic Safety Compliance, stated that employee empowerment and taking personal responsibility for safety can reduce incident rates in the workplace.[16] This concept compliments the employee involvement principle of an effective Safety and Health program and can be thought of as an injury and illness prevention strategy.

There are several research papers on behavior-based safety and its effectiveness as well as case reports from companies with successful behavior-based safety training programs. The paper, Beyond Training: Organizational Performance Management Techniques, notes that in the safety arena, the science of behavior has been increasingly used to address the human aspect of injury prevention.[17] Despite training, workers have returned to earlier bad habits, failed to use, circumvented, or misused proper precautions. The applied branch of behavioral science known as performance management looks at these issues. Performance management sees behavior as a function of prior and current events that influence performance. Contextual factors and antecedents or happenings that precede the performances of concern are important but consequences or events that follow exert the heaviest influence on behavior. Consequences can be reinforcing or aversive. To use this information practically, performance managers undertake an ABC analysis (Antecedents-Behavior and Consequences) of the unwanted and preferred behaviors on the job. Specifically, they look at which antecedents and consequences precede and follow each class of behavior. The consequences are classified as positive or negative, immediate or delayed, highly or minimally probable, and how meaningful they are to the worker at that time. To successfully change behavior, reinforcers should be primarily positive. Consequences should be immediate, and need to occur regularly. Consequences must be meaningful to the individual and specific feedback is an effective example. This study lists 44 published papers of performance management safety interventions. The authors feel that performance management is a valuable tool within the total safety and health program.

The use and effectiveness of behavior-based safety was evaluated in the article, Researching Behavior-Based Safety: A Multi-Method Assessment and Evaluation.[18] Advantages of a behavior-based safety process are that it can be administered by an individual with little professional training. It can affect workers in the setting where the problem occurs. Management can be taught the behavior-based technique most likely to work under their specific circumstances. It is cost-effective because the tactics are straightforward and relatively easy to administer. Progress can be assessed by personnel monitoring the target behavior without any special tools. A nationwide survey of safety professionals revealed that 80% believed that behavior-based safety was a viable approach for reducing at-risk work behaviors. Most respondents indicated that they had an accurate but narrow awareness of what behavior-based safety entailed. The majority saw behavior-based safety as an observation and feedback tool rather than a general strategy to improve the human aspect of safety. Few survey participants used the percent safe behaviors to monitor the success of their programs. Other outcome measures such as OSHA recordables, lost-time accidents or total recordable injury rates were used instead. These results point out that behavior-based safety is in use and felt to be a credible technique but that there are some misconceptions and misapplications of this approach.

In a companion article also by Geller et al titled, Critical Success Factors for Behavior-Based Safety: A Study of Twenty Industry-Wide Applications, his group reported on interviews and focus group meetings at twenty organizations that had implemented a behavior-based process for at least one year.[19] The main method used by every company that reported reduction of injuries with behavior-based safety was observation and feedback. These tactics required employee participation for success. Five variables were predictive of employee involvement in the behavior-based safety process. These were: perceptions that behavior-based training was effective, trust in management abilities, accountability for behavior-based safety through performance appraisals, education in behavior-based safety, and tenure with the company.

The article by Gilmore and Perdue stated in the title that behavior-based safety is the next step in injury prevention.[20] They discussed how the behavioral approach to safety performance improvement had recently been developed in the last part of the 20th century. It attempted to understand employee behaviors in the context of their work culture. This enlightenment was used to reduce hazards for the employees. Behavior-based safety principles have been used in the form of a behavioral observation and feedback process. This process works by increasing the frequency of safe behaviors and by decreasing the number of at-risk behaviors. These techniques are similar to those used in the field of performance management. In spite of the author's support of this process, they feel that true change in safety performance will require more than a successful behavior-based safety program. Individuals must work together for the safety of one another. All these behavioral change interventions need to have a positive impact on the safety culture of the organization. The ultimate goal is Total Safety Culture. This is defined as a culture in which the individuals hold safety as a value, feel a sense of responsibility for the safety of themselves and their fellow workers, and are willing and have the skills and tools to go beyond the call of duty for the safety of others.

Concerning behavior-based training, the paper by Groover discussed the need in industrial safety and health to engage personnel at all levels to motivate themselves and each other through hands-on action planning for performance improvement.[21] The practice of behavior-based training focuses on four main concepts. The first principle is that the goal of training is behavioral change. This is followed by the concept that some behaviors are harder to change than others. Behavior change often requires system change. Finally, to change the wage worker's behavior, expect to change management's behavior. The point of behavior-based training is to help trainees reduce the number and frequency of their identified at-risk behaviors and increase the number and frequency of safe behaviors before an incident or injury occurs. This is accomplished by analyzing the antecedents and consequences for the at-risk behaviors and the antecedents and consequences for the safe behaviors and then formulating an action plan.

The discussion by Roberts in the article, Employees Forgot Their Hard Hats Again? Seven Lessons from Behavior-Based Safety for Increasing PPE Use gave a practical application for this strategy.[22] The first critical concept for success of behavior-based safety is to involve the employees in an observation and feedback process. It is necessary to reinforce the targeted PPE behaviors. The factors influencing PPE use must be considered. It is important to know which factors contribute to safe behaviors and which contribute to at-risk behaviors. Workers need to be involved in determining appropriate interventions. The focus of feedback needs to be on the potential for injury, not the safety rules. This can be done more effectively by using examples, images, and case studies not just injury statistics. Finally, consider the issues beyond PPE use. Although PPE use is under the control of the individual, there are multiple causes for injury that may not be under the control of the individual. Management's willingness to address the factors influencing at-risk behaviors under their control will increase feelings of trust and teamwork. This sense of management commitment will increase employee participation in safety efforts under their control.

In Behavioural Safety: A case study from ICI Autocolors, Stowmarket, this UK company chose the B-Safe Programme.[23] Initially, the evaluation of 31 work areas revealed only 48% safe behaviors. After 43 weeks of this behavior-based program, the areas increased to an average of 86% safe behaviors. This change in safety prevention strategy resulted in a reduction of their accident rate by 40% in the first year. The case report, Employee-Driven Behavioral Change Improves Safety described another behavior-based safety success story.[24] The lost-time injury rate went from 6.3 to 2.1 after implementing a behavior-based safety program for one year at Olympic National Park in Washington state. The organization used employee-driven strategies to improve safety communication and positive reinforcement to motivate safe work behavior resulting in a total safety culture.

There were no articles discovered that used behavior-based techniques to specifically target the reduction of amputation injuries.

Materials and Methods

Because it was necessary to maintain confidentiality of the workers compensation data from the Florida Bureau of Workers Compensation, demographic data from the workers in the amputation and control groups were not used. The data sets for the amputation injury group and the control group were accessed by the computer specialist for the USF Safety Florida Consultation Program and interfaced into the mail merge for the cover letter and survey of the selected companies.

Analysis of Bureau of Labor Statistics Data

Data was obtained from the Federal and Florida Bureau of Labor Statistics for amputation injuries in the US and Florida. The Federal BLS collects data annually from a sample of approximately 200,000 private establishments. The Florida BLS collects data from 11,000 private establishments. The data include all recordable injuries or illnesses. The case and demographic data involve all cases with at least one lost workday. Age, gender, occupation, and length of absence are required information but race, ethnicity and years employed are optional. The case data delineates the type of injury, the body part injured, the source of the injury, and the event that created the injury. This data comes from the OSHA logs for injury and illness for each company surveyed. The summary data were analyzed for the numbers and incidence rates, and trends in amputation injuries. The case and demographic data were analyzed for age, gender, race and ethnicity, years employed, occupation, major industry category, body part injured, source of injury and the event surrounding the injury. This data was also compared between the national and state groups.

Source and Event for the Amputation Injury

Each injury or illness reported to the Florida Bureau of Workers Compensation has a separate field describing the events surrounding the injury. A random sample of this description of injury field for 50 of the amputation injuries from the cohort group was analyzed for the source of injury and the method of injury. This was done to assure that the cohort group was similar to the Florida and national workers with amputation injuries and could be done without breaching confidentiality of the case or the company.

Amputation Prevention Strategy Survey

A cohort and control group of Florida companies were selected for participation in a self-designed survey concerning amputation injuries and prevention strategies for workplace amputations. The workers compensation data from the Florida Bureau of Workers Compensation within the Department of Insurance was made available to the USF Safety Florida Consultation Program for research purposes. The data was queried for all the amputation injuries for the years 1999, 2000, and 2001. This was done using the 200 code for amputations and the 4700 code for severance. Amputation was defined as cut off extremity, digit, or protruding part of the body. Severance was defined as to separate, divide or to take off. This query yielded 420 companies that had reported one or more amputation injuries to the Florida Bureau of Workers Compensation. A control group of 420 Florida companies was randomly selected from the same data base for the same years of 1999, 2000, and 2001. This group could have any type of work-related injury or illness except amputation or severance. The surveys were mailed to the company name and address listed on the workers compensation data base. The surveys were addressed generically to the owner/safety professional of that selected company. No specific contact names were obtained. The surveys from the amputation group were marked with a 47 to designate that group.

Survey Content (Figure1)

Question 1

The survey participants were asked to list the SIC (standard industrial code) for their company. The companies were then placed into the appropriate major industrial category based on their response. A category for unknown was added. The major categories used were agriculture, forestry, and fishing, mining, construction, manufacturing, transportation and public utilities, wholesale trade, retail trade, finance, insurance, and real estate, services, and public administration. The manufacturing category was subdivided to reflect the special areas designated by the OSHA Emphasis Program on amputations. These high risk categories were lumbar and wood products, furniture and fixtures, primary metal industries, fabricated metal products, and industrial machinery and equipment.

Question 2

The survey participants were asked to fill in the number of amputation injuries, if any, for each of the years of interest. This information would be readily available from the company OSHA logs for injuries and illnesses since an amputation injury would be recordable in nearly 100% of the cases.

Question 3

The participants were given a list of ten strategies that might be used to prevent amputation injuries. The participants were instructed to check as many strategies as were applicable for their company. The question was designed to cover a wide range of elements of a Safety and Health Program such as job site analysis, management commitment, employee involvement, administrative controls, engineering controls, analysis of injury and illness trends and near misses, and behavior-based as well as traditional safety training.

Question 4

The participants were asked to evaluate any changes that were made to their safety training after an amputation injury occurred. The participants could choose to respond yes, no, or not applicable. If the participant chose yes, they could select up to four options such as behavior-based safety training, additional traditional safety training, safety committee investigation, or other.

Question 5

To determine if there was a prevention technique not listed in the survey that might be valuable in decreasing injury or illness rates, the participants were given the option to write in a response to this question and share their successful strategies.

Figure 1

SURVEY

1. What is the Standard Industrial Classification (SIC) for your business?
2. Did your company report any amputation injuries in the following years?
   1999 Yes_____ # of injuries_____ No_____
   2000 Yes_____ # of injuries_____ No_____
   2001 Yes_____ # of injuries_____ No_____
3. What specific actions has your company taken to prevent amputation injuries? Please check as many of the following that apply.
   ____Performed job site analysis to identify amputation hazards
   (i.e. power presses, press brakes, saws, shears, and slicers, nip points, pinch points, shear points)
   ____Eliminated the amputation hazards or changed the work process to avoid amputation hazards
   ____Held employee training on amputation hazards
   ____Instituted any form of behavior based safety training which identifies critical safety related behaviors, develops preventive actions, measures compliance through observation, and provides feedback for improvement that is soon, certain, and positive on an ongoing basis.
   ____Analyzed trends in injury and illness logs (OSHA 200 and 300 logs)
   ____Performed preventive maintenance of hazardous machinery
   ____Emphasized administrative support for a safety culture
   (i.e. bonuses or promotions tied to a decrease in amputation or general injury rate)
   ____Encouraged employee involvement in prevention with a defined complaint or suggestion procedure with feedback from management
   ____Evaluated near-miss incidents
   ____Instituted engineering controls for amputation hazards
   (i.e. machine guarding, light curtains, additional safety devices or warning signage)
4. In regard to safety training, did you make any specific changes to your safety training program after the amputation(s) injury occurred?
   Yes_____ No_____ NA_____
   If yes, what were the changes?
   Check as many of the following that apply.
   ____Held more frequent training sessions on amputation hazards
   ____Instituted any form of behavior based safety training program
   ____Assigned safety committee to investigate the amputation hazard and make recommendations for training and prevention
   ____Other
5. Is there any program or method that you have instituted as part of your safety and health program that has been particularly effective in decreasing injury or illness rates?

Results

Summary Data for US and Florida Bureau of Labor Statistics (Figures 2,3)

The number of amputation injuries for the years 1997, 1998, 1999, and 2000 are plotted graphically to show the trends in injury numbers for the US and Florida. For the US, there was a 5.6% decrease between 1997 and 1998. There was a 2.5% decrease between 1998 and 1999. There was a 3.3% decrease in amputations between 1999 and the year 2000. In Florida, there was a 17% increase between 1997 and 1998 but a 19.4% decrease between 1998 and 1999. Then between 1999 and 2000, there was a 62.3% increase in amputations in the state of Florida. The incidence rates for amputation injuries represent the number of injuries per 10,000 full-time workers. They are also plotted graphically and used to show the trends in amputations as well as a visual comparison between the US and Florida. The downward trend in amputation injuries in the US and the recent increase in amputations in Florida is even more apparent on the incidence rate graph.

US Bureau of Labor Statistics (Table 1)

For the amputation injuries in the year 2000, the mean age of the worker was 35 to 44. This worker was usually a white, non-Hispanic male. He had been working with his company 1 to 5 years before the amputation injury occurred. The most common jobs for amputation injuries were operators, fabricators, and laborers in the manufacturing industry. The source of the injury was most often a machine. The body part which was usually a finger was caught in, compressed, or crushed by the machine.

Figure 2

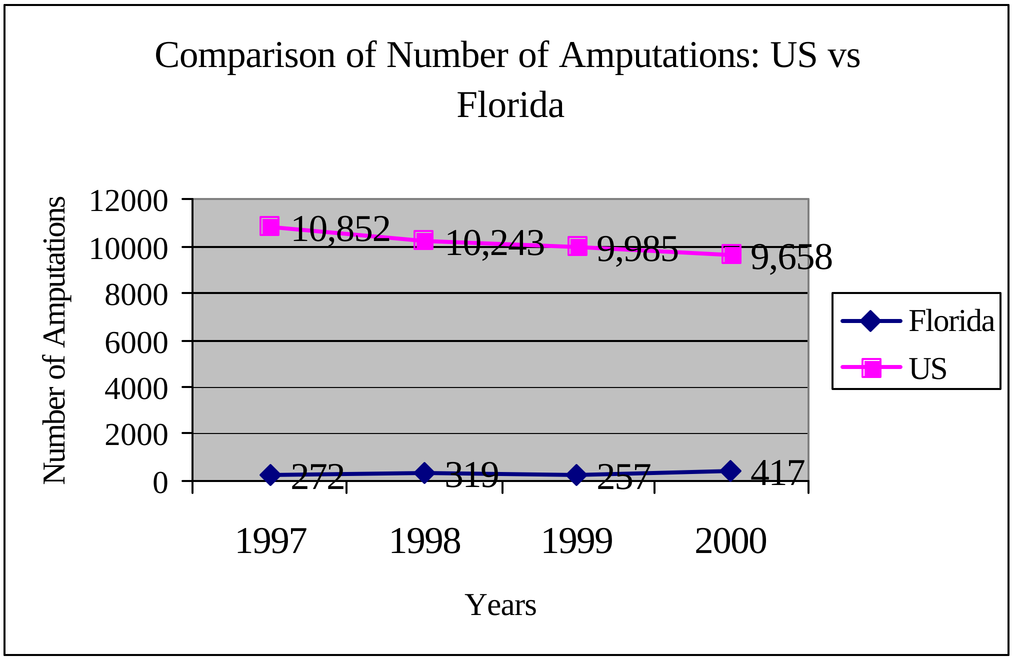
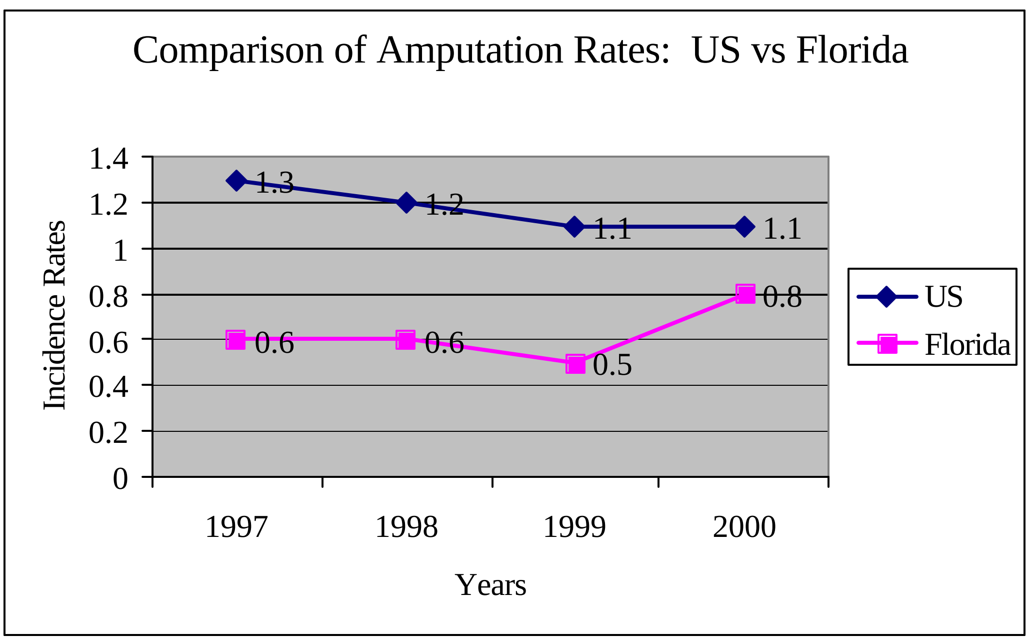


Figure 3



Florida Bureau of Labor Statistics (Table 1)

The Florida Bureau of Labor Statistics gives us a snapshot of the demographic data and the case characteristics of amputation injuries in the state. For the year 2000, most all of the workers were male between 35 and 44 years old. The majority of the workers were Hispanic and the rest were white, non-Hispanic. 29% had less than 3 month length of service with their employer, and 35% had 1 to 5 years service prior to their amputation injury. The most frequequent occupations of the workers were in the agriculture, forestry, and fishing industries, or in the precision production, craft or repair industries. Most all of the amputations involved the upper extremity with nearly all of the amputations occurring to the fingers. Machinery and parts and materials were responsible for the amputations. This happened by contact with an object or equipment. Most events involved being caught in the object, equipment, or material and the rest occurred by being struck by the object.

Table 1

Amputation Demographic and Case Data for 2000

	Florida	US
Total	417	9,658
Major Industry Division		
Agriculture, Forestry, Fishing	151	703
Mining		127
Construction		1,143
Manufacturing	94	4,516
Transportation, Utilities		364
Wholesale Trade		956
Retail Trade		1,196
Finance, Insurance, Real Estate		121
Services		532
Gender		
Male	343	8,397
Female		1,171
Not reported		89
Race or Ethnic Origin		
White, non-Hispanic	79	5,072
Black, non-Hispanic		730

Hispanic	244	1,872
Asian or Pacific Islander		189
American Indian, Alaskan Native		51
Not reported	82	1,744
Age		
16-19		560
20-24	59	1,223
25-34	61	2,277
35-44	197	2,728
45-54		1,661
55-64	59	1,041
65 and over		107
Not reported		61
Length of Service		
Less than 3 months	121	1,652
3 months to 11 months	72	1,842
1 year to 5 years	148	3,141
More than 5 years	65	2,415
Not reported		607
Occupations Groups		
Managerial/Professional		106
Tech, Sales, Adminstrative support		423
Service	72	814
Farming, Forestry, Fishing	151	734
Precision production, craft, repair	107	2,378
Operators, fabricators, laborers	58	5,184
Part of Body Affected		
Upper Extremity	348	9,163
Finger	343	8,810
Hand, except finger		192
Lower Extremity	69	495
Foot, toe	68	374
Source of Injury		
Containers		302
Machinery	245	5,429
Parts & Materials	107	1,130
Floors, walkways or ground surfaces		54
Hand tools		1,203
Vehicles		739
All other sources		762
Event Leading to Injury		
Contact with objects	415	9,340
Struck by object	82	1,921
Struck against object		777
Caught in object, compressed, or crushed	311	6,559
Transportation accidents		102
Fires & explosions		115
All other events		83

Comparison of Demographic and Case Data between US and Florida

Comparison of the demographic and case data between Florida workers with amputation injuries and US workers with amputation injuries revealed many similarities.

The most prevalent gender and age categories were the same. The most frequent industry division represented in Florida was agriculture, forestry, and fishing as opposed to manufacturing for the US. This reflects the prominence of agriculture in Florida with the large numbers of citrus and produce industries in the state. The most prevalent occupation group for amputations in Florida was farming, forestry, and fishing. This parallels the major industry division represented. The greatest occupation category for the US was operators, fabricators and laborers which reflects the major industry division of manufacturing. There were more Hispanic workers with amputations in Florida than whites. This mirrors the increased numbers of Hispanics in the workforce in Florida as well as their employment in agriculture. Florida has the fourth largest population of seasonal and migrant farm workers and 86% of them are Hispanic. The US data showed a preponderance of white, non-Hispanic workers with amputations. Florida and the US had the most amputation injuries in the group with one to five years of service. Florida proportionally had more workers with amputations who had been working less than three months when compared to the US workers. This could reflect a lack of training issue. In both groups, the most frequently affected body part was the finger. The greatest source of injury was machinery for the Florida and US groups. The event leading to the injury was contact with an object for the two groups. Most often, the affected part was caught in the object, compressed, or crushed followed by being struck by the object for the injured workers in Florida and the US.

Source and Event for the Amputation Group (Table 2,3)

For the 50 random description of injury fields, the sources of injury were machinery and parts or materials, followed by handtools, and vehicles. The event was always contact with the object or equipment. Most of the amputations occurred because the body part was caught in the object, equipment, or material. Nine happened when the injured part struck against the object and 6 occurred when the affected part was struck by the object.

Table 2

Source of Injury

Hand tools	4
Machinery	22
Parts & Materials	22
Vehicle	2

n = 50

Table 3

Event: Contact With Object or Equipment

Struck by	6
Struck against object	9
Caught in object, compressed, or crushed	35

n = 50

Survey Results

840 surveys were mailed out to the companies in Florida with and without amputation injuries for the years 1999, 2000, and 2001. 146 surveys were returned as undeliverable with no forwarding address. 86 were in the amputation group and 60 were in the control group. Two companies stated that they would be unable to participate in the survey. One was in the amputation group and the other was in the control group. Out of the remaining 692 surveys, 35 surveys were returned in the amputation group for a response rate of 10.5%. In the control group, 35 surveys were returned for a response rate of 9.7%.

Survey results

Question 1 (Table 3)

Question one asked for the SIC code for the company. Of the 35 companies in the amputation group, all of the Standard Industrial Codes (SIC) were represented except mining and public administration. In the manufacturing subgroups, four of the high risk industries responded to the survey. There was one from the furniture and fixtures subgroup, two from primary metal industries, and one from fabricated metal products. In the control group, all the SIC groups were represented except agriculture, forestry, and fishing, and mining. One high risk industry responded to the survey in the control group. This was a lumber and wood products company. There were differences in the percentages of the SIC representation between the amputation group and the control group. The amputation group had more unknowns than the controls. Manufacturing was highly represented in the amputation group (20% vs 8.6%). Adding the high risk manufacturing subgroups to the general manufacturing category, increased the differences between these groups to 31.4% vs 11.5%. The control group had more companies responding from service industries (37.1% vs 14.3%). Public administration was represented in the control group by three companies and by none in the amputation group.

Table 3

SIC for Amputation and Control Group

SIC Class	Amputation	%	Control	%	PeRcent DIFFERENCE
Unknown	6	17.1%	4	11.4%	5.7%
Agriculture, Forestry, Fishing	1	2.9%	0	0%	2.9%
Construction	4	11.4%	2	5.7%	5.7%
Manufacturing	7	20%	3	8.6%	11.4%
High Risk Manufact.	4	11.4%	1	2.9%	8.5%
Tranportation, Utilities	1	2.9%	2	5.7%	2.8
Wholesale trade	3	8.6%	2	5.7%	2.9%
Retail trade	3	8.6%	4	11.4%	2.8%
Finance, Insurance, Real Estate	1	2.9%	1	2.9%	0%
Services	5	14.3%	13	37.1%	22.8%
Public Admin.	0	0%	3	8.6%	8.6%
TOTAL	35		35		

Question 2 (Table 4)

For the year 1999, the amputation group listed 8 amputation injuries and the control group had none. For the year 2000, there were 5 injuries in the sturdy group and none in the control group. For the year 2001, there were 6 amputation injuries in the amputation group and none in the control group. Three companies had more than one amputation injury. Of the 35 companies in the study group, only 15 or 42.9% claimed amputation injuries for any of the three years of interest. The other 20 companies or 57.1% did not list any amputation injuries even though their names were selected from the amputation group database. To determine the true error rate for the workers compensation data, the description of injury fields for all 420 selected amputation injuries were reviewed. There were 55 injuries that were misclassified in the amputation group for an error rate of 13%. The inaccuracy occurred mostly with the severence code and not the amputation code. The term severence had been used to describe a separated shoulder or separated ribs, for example.

Table 4

Frequency of Amputations

1999			
Amputations		**Controls**	
Yes	**No**	**Yes**	**No**
8	27	0	35
2000			
Amputations		**Controls**	
Yes	**No**	**Yes**	**No**
5	30	0	35
2001			
Amputations		**Controls**	
Yes	**No**	**Yes**	**No**
6	29	0	35
1999-2001			
# Companies Claiming Amputations			
Yes		**No**	
15		20	

Question 3 (Table 5,6)

The raw data for each prevention strategy reponse was tabulated by the corresponding SIC in Table 5. Each of the 10 prevention strategy choices were compared separately between the amputation group and the control group using chi square. For each 2x2 table there was one degree of freedom. The critical chi square for 1 df was 3.841. The numbers listed in Tables 5 and 6 represent the yes responses for both groups except for the none category. The no responses were calculated by subtracting the number of yes responses from 35 (# participants in each group) and then subtracting the number of none responses for that specific group (2 in the ampuation group and 7 in the control group). It was determined that the participants that chose not to select any choices (none category) would be not be analyzed. Since the purpose was to compare prevention strategy choices between the study group and the control group, there would be nothing to compare among two groups that didn't select any prevention strategies.

There were no significant differences between the prevention strategy choices among the two groups except for choice #5 which was analysis of the OSHA log trends. This was significant for an alpha of 0.05. Because multiple chi square tests were performed, this increased the probability of a Type I error and significance occurring by chance alone. A type I error occurs when a true null hypothesis is rejected. To correct for this problem, the Holm procedure was applied to the p values. The p_i values were placed in increasing numerical order. P_1 is the smallest and P_n is the largest. Then each p_i value was compared with alpha/(n – i + 1) for rejection. Starting with the smallest p value, one continues applying these comparisons until the first nonrejection is encountered. In this case, n equals 10 (from the 10 chi squares). The p value for strategy choice # 5 was the smallest so it was given #1 in the rank order. Therefore, the formula calculated as 0.05/(10 – 1 + 1). Solving this equation gave an adjusted alpha of 0.005. The obtained p value of 0.019 is larger than 0.005 and now the null hypothesis is not rejected and this choice is no longer significant. There was no significant difference in the number of responses chosen between the amputation group and the control group. These results are presented in Table 6. A logistic regression was also performed on the prevention strategy data. Logistic regression is used to obtain predicted probabilities that a unit of the study population will acquire the event of interest (dependent variable) as a linear function of one or more independent variables. The logistic regression was not significant for any or all independent variables.

Table 5

Prevention Strategy Reponses by SIC

Amputations											
SIC	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**None**
Unknown	3	4		2		3	1	1	1	2	
Agriculture, Forestry, Fishing	1			1		1		1	1	1	
Construction	2	2	4			2	2	2	1	2	
Manufacturing	4	3	6	4	3	4	2	4	4	4	
High Risk Manufacturing	3	3	2	1	1	2	1	3	3	3	1
Transportation, Utilities	1										
Wholesale Trade	1	1	1	2	1	2	1	1	1	2	1
Retail Trade	3	1	3	2	1	2	1	1		1	
Finance, Insurance, Real Estate			1	1			1	1			
Services	2	1	1	4	2	3	3	2	2	3	
TOTAL	**20**	**15**	**18**	**17**	**8**	**19**	**12**	**16**	**13**	**18**	**2**
Controls											
SIC	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**None**
Unknown	2	1		3	2	2	2	2	2	1	
Construction	2	1	1	2		1	2	1	1	1	
Manufacturing	3	2	3	2	1	3	2	2	2	2	
High Risk Manufacturing			1					1			
Transportation, Utilities	2	2	1	1	2	2	2	1	1	2	
Wholesale Trade	1			1	1	1		1			1
Retail Trade		1		2		1		1	1	1	2
Finance, Insurance, Real Estate				1		1	1	1			
Services	6	5	5	8	8	8	2	8	5	6	2
Public Administration	1				1					1	2
TOTAL	**17**	**12**	**11**	**20**	**15**	**19**	**11**	**18**	**12**	**14**	**7**

Key
1=Identify amp hazards
2=Eliminate amp hazards
3=Hazard training
4=Behavior-based training
5=OSHA log trends
6=Machinery maintenance
7=Admin. Support
8=Employee Feedback
9=Evaluate near-misses
10=Engineering controls

Table 6

Comparison of Amputation Prevention Strategies

strategy	Amputation	Control	chi square	P Value
Identify amp hazards	20	17	0.0001	0.993
Eliminate amp hazard	15	12	0.041	0.839
Hazard training	18	11	1.421	0.234
Behavior-based training	17	20	2.517	0.113
OSHA log trends	8	15	5.547*	0.019*
Machinery maintenance	19	19	0.681	0.409
Admin. Support	12	11	0.055	0.815
Employee feedback	16	18	1.532	0.216
Evaluate near-misses	13	12	0.075	0.784
Engineering controls	18	14	0.006	0.939
Total # of responses	156	149	0.28	
No strategies chosen	2	7	NA	

Critical ?² = 3.841
* significant with a of 0.05

Question 4 (Table 7)

This question focuses on the changes made after an amputation injury occurred so only the companies in the amputation group were analyzed in this case. The initial choices for this question were yes, no, or not applicable. The 20 companies that did not claim any amputaion injuries were listed as not applicable because in their mind, they had no amputation injuries. Any changes made to their safety training program after an amputation injury would not apply. Of the remaining 15 companies, there were 21 responses to this question. Eight of the 15 companies or 42% made no changes to their safety training after the amputation injury occurred. Seven companies stated that they had made some changes to their safety training programs after the injury occurred. Three companies held more frequent training sessions on amputation hazards. Two companies instituted behavior-based safety training. Five companies assigned the safety committee to investigate the amputaion hazard and make recommendation for training and prevention. Under the other response choice, one company included 10 and 30 hour OSHA training, and one company improved their machine guards.

Table 7

Post-Amputation Safety Training Program Changes

changes	# of responses	Frequency
NA: no amputations claimed	20	20/35=57.1%*
No	8	8/35=22.9%*
Yes	7 (12 choices)	7/35=20%*
More training	3	3/7=42.9%**
Behavior-based training	2	2/7=28.6%**
Safety Committee investigation	5	5/7=71.4%**
Other	2	2/7=28.6%**

* Frequency based on total # of participants in amputation group
** Frequency based on total number of participatants responding yes

Question 5

The comments to this question varied but therewere a few common themes. The amputation group had 16 responses to this question which concerned any program or method that was effective in decreasing injury or illness rates. Several companies commented on the use of a safety committee or scheduled safety meetings. A few participants mentioned the importance of management commitment and presence at the worksite. Others had variants of a safety committee that were successful such as a safety report card, safety improvement teams which focused on accidents and prevention, and a safety advisory commmitttee that had budget resources to act on the recommendations of the safety committee. Two companies evaluated compentency before allowing employees to operate dangerous equipment. Two companies enforced safety rules strictly with discipline or time off for non-compliance with the rules. Two companies mentioned the importance of a drug free workplace and drug testing. Employee involvement in accident and illness investigation was listed as an effective technique. One company allowed employees to refuse to operate equipment without safety devices in place. Other successful strategies included behavior-based safety training, safety culture mindset with constant reinforcement, and best practices for safety and work performance. One compny felt that video presentations for safety training were helpful. One respondant thought that the OSHA 10 and 30 hour training courses were effective. An ergonomics committee was a useful method at one company.

The control group had 18 responses to this question. The control group mentioned similar successful approaches to decreasing injury and illness rates. Safety meetings and regular training were mentioned by several companies. Two of theses involved the use of safety incentives. One company had a shop safety program jointly conducted by safety inspectors and the shop curriculum specialist. Another used annual inspections from risk management as an effective technique. Several participants focused on hazard recognition, followed by elimination of the hazard or specific engineering controls. One company cited the importance of support from administration. One company felt that repetition in training was a successful method. Investigation of accidents and near-misses worked well for one company. Equipment training and providing state-of-the-art equipment to improve the working conditions were two effective strategies listed. Ergonomic assessments and corrections were helpful in decreasing rates according to one respondant. One company with a knive hazard did not allow minors to use knives at the workplace. They also made sure the hazardous tasks were done during slow work periods. A quality improvement process worked well for one company.

Overall, the concepts of continual assessment, evaluation, and training along with making safety a priority resulted in positive outcomes for these companies.

Discussion

According to the literature search, there is little information on the topic of amputations in the workplace. There are no studies on prevention strategies for amputation injuries other than those involving machinery. Most of the data indicates that the amputations occur when an employee is using machinery or parts or materials and is either struck by the object or caught in, crushed or compressed by the object. This information led OSHA to develop its Emphasis Program on Amputations and to recognize high risk industries and sources of amputations such as power presses, machines, slicers, and saws. The main solution offered so far is engineering controls, especially machine guarding. This seems to have led to a gradual decrease in the amputation rate in the US although not in Florida.

Traditionally, safety prevention has been done in the form of a program training process for each element and education from post-accident investigation. In the study by Vojtecky and Schmitz , it pointed out that the people responsible for safety training aren't even sure if it is effective.[25] Safety training and post-accident investigation both heighten awareness at the time of the training or the accident. This awareness tapers off as time elapses. To prevent this, safety needs to be on everyone's mind every day and this is difficult to accomplish. The article, Continuous Safety Progress Focuses on "Upstream" Factors in Analyses discussed the accident cycle and ways to break free of it.[26] An increase in incident rates triggers more attention to safety until performance improves and then the attention is directed elsewhere. Krause suggests the way to continuous safety progress is through behavior-based safety systems. Perhaps the system needs to be adjusted so it won't allow accidents to happen. Investigation into medical errors has come to the conclusion that the individuals want to do the right thing but the system doesn't always allow that to occur.[27] Engineering controls such as machine guarding are one way to remove the hazards from the system. Another proactive approach is the use of a behavior-based safety program. As previously reviewed, this technique involves management commitment to the program, employee involvement in the process as well as maintaining an awareness of safety and changing behavior by reinforcing safe behaviors and altering unsafe ones BEFORE an accident occurs. This concept appears to be in use in Florida. 48.6% of the companies with amputation injuries were using it as a prevention strategy and 57% of the companies without amputation injuries listed it as a prevention strategy.

External Validity

The source of injury and the event for the amputation study group were compared with the Bureau of Labor Statistics data for Florida and the US. The most frequent sources of injury for the study group were machinery and parts & materials. This is comparable to the two largest groups for Florida and the first and third largest groups for the US. The most frequent group in the event category for the study population was caught in the object, compressed, or crushed. This was the same for the Florida and the US Bureau of Labor Statistics dataset. This analysis implies that the amputation study group is generalizable to other workers in Florida and the US at least for the source of injury and the event.

Study Limitations

The surveys were sent out using the addresses that the companies gave to the

Department of Insurance when the injury was reported. Despite this, 146 were returned without being delivered. 58.9% were in the amputation group and 41% were in the control group. There were more unavailable companies in the amputation group and this factor may have been important. These unavailable companies may have gone out of business for a variety of reasons which could include poor safety habits and may have been different from the companies that actually received the surveys.

The two companies that were unable to participate were equally represented between the control and study group. They stated that they were not allowed to participate for legal reasons and a corporate policy on surveys. This number of non-participation was too small to affect the study results.

The number of non-responders in each group was large. There were 334 non-responders in the amputation group and 360 non-responders in the control group. Not only did this result in small numbers for analysis in each group, the non-responder group may have been different than the companies that chose to respond. The cover letter suggested that participation in the survey would result in information that could benefit their company by decreasing injury rates and workers compensation costs. Perhaps this statement was not enough incentive to participate. Maybe other companies were concerned about the legal issues of giving out company information. The companies in the amputation group may not have felt comfortable admitting that they had an amputation. It would be interesting to know why the companies chose not to return the surveys.

There was a problem with misclassification among the amputation group. Over half of the companies selected to the amputation group did not report an amputation injury for the years of interest. Taking into account the error rate of 13% for misclassification of the amputation injuries by the Department of Insurance, this still leaves 44.1% of amputations unaccounted for in the study group. This information should have been available from the OSHA logs for 1999, 2000, and 2001. Without violating the confidentiality of the study and making contact with the safety professionals for the companies, there is no way to uncover the reason for this misclassification. Again, it is possible that the companies with amputation injuries were reluctant to admit this information to a voluntary and unknown source.

By design, the participants were divided into the amputation and control groups and then identified only by their Standard Industrial Classification. There were differences between the two groups based on this classification which could be viewed as a confounder. A confounder is a third factor that affects the outcome but isn't the independent variable. In this study, the independent variables are the prevention strategies and the outcome is the amputation injury. The amputation group had more representation from industries involved in manufacturing including those at high risk for amputations. The control group had more representation from service industries and public administration which are low risk industries for amputation injuries. Since there were many choices for selection of the control group, this confounder could have been controlled for by matching the control group to the frequency of the SIC divisions in the amputation group.

There was a difficulty with the validity of the results for the main survey question involving the prevention strategies amputation injuries because of the small sample size. There was an increased probability of a Type I error due to multiple chi square testing.

This was adjusted for using the Holm Procedure. Although the differences between the study group and the control group were not significant, there was not enough power to conclude that the non-significant findings were truly not significant or due to a Type II error. There were 9 participants that chose to select no prevention strategies for that survey question. Two were in the amputation group and 7 were in the control group. Since it would be inappropriate to compare the use of no prevention strategies among the two groups, these numbers contributed to lowering the number of responses available for chi square calculation. If the survey return rate had been 40% instead of 10%, and the differences between the two groups had been at least 18, the results would have been significant.

The near significant strategies for the control group were analysis of injury and illness trends from the OSHA logs, behavior-based safety training, and employee involvement and feedback. The only near significant strategy for the amputation group was employee training for amputation hazards. The control group appears to be using more global safety approaches and the amputation group is focusing on more narrow, specific tactics.

An area of concern was the 8 companies out of 15 who claimed an amputation injury but made no changes to their safety training program afterwards. It seems that a significant injury like an amputation would trigger an investigation and perhaps some proactive changes to prevent any further injuries. One company wrote that their workers compensation insurance carrier investigated the amputation injury and found that it was due to the employee's carelessness and not to any deficiencies in their safety program. There may have been similar circumstances with other companies.

Conclusion

The data clearly show that amputation injuries occur in all industries not just in the high risk manufacturing companies. Therefore, it would be important to find a universal strategy that could prevent these injuries and be applied in all types of industry. It was hoped that this study would uncover a specific successful strategy(s) that could be used by all companies in Florida to decrease the amputation rate in the state. Areas of promise include analysis of trends in injury from OSHA logs, a behavior-based safety program, and employee involvement and feedback. Once initiated in Florida, the OSHA Emphasis Program on Amputations may be effective for high risk industries. Since there was not evidence of any one significantly successful strategy, further research in this area would be beneficial. A nested case-controlled study in a high risk amputation industry using one specific strategy such as a behavior-based safety program could be used to evaluate the effect of this strategy on the company's amputation rate.

Research References

1. United States Department of Labor. Bureau of Labor and Statistics. Available at http://www.bls.gov/iif. Accessed July, 2002.

2. Florida Department of Labor and Employment Security. Bureau of Labor and Statistics. Available at http://www@fdles.state.fl.us. Accessed July, 2002.

3. Krause T. The Behavior-Based Safety Process. New York, NY. Van Nostrand Reinhold Publishers. 1990.

4. Etherton JR, Myers ML. Machine Safety Research at NIOSH and the Future Directions, International Journal of Industrial Ergonomics. 1990, Volume 6, 163-174.

5. OSHA Instruction: National Emphasis Program on Amputations. US Dept of Labor, Occupational Safety and Health Administration. March 26, 2002. Directive No. CPL 2-1.35.

6. CDC, 2001, Nonfatal Occupational Injuries Treated in Hospital Emergency Departments-United States, 1998. MMWR. Morbid Mortal Wkly Report, 50(16): 313-7.

7. Injuries and Amputations Resulting from Work with Mechanical Power Presses. Cincinnati, Ohio: Dept of Health and Human Services (NIOSH). May 22, 1987. Publication No. 87-107.

8. Boyle D, Larson C, Parker D, Pessoa-Brandao L. Medical, Personal, and Occupational Outcomes for Work-Related Amputations in Minnesota. Amer J Ind Med. 37(5): 551-7, 2000 May.

9. Boyle D, Larson C, Parker D, Pessoa-Brandao L. Nature, Incidence, and Cause of Work-Related Amputations in Minnesota. Amer J Ind Med. 37(5): 542-50, 2000 May.

10. Cook S, Long L. MIOSHA's Strategic Plan for Reducing Amputations in Michigan. Available at http://www.michigan.gov/cis. Accessed August, 2002.

11. Safeguarding Equipment and Protecting Workers from Amputations. U.S. Dept of Labor, Occupational Safety and Health Administration. 2001. Publication OSHA 3170.

12. OSHA Fact Sheet: Amputations. U.S. Dept. of Labor, Occupational Safety and Health Administration. 2002.
13. Vojtecky M. Education for Job Safety and Health. Health Education Quarterly. Vol. 15(3): 289-298. Fall 1988.

14. Goldenhar L, Moran S, Colligan M. Health and Safety Training in a Sample of Open-Shop Construction Companies. Journal of Safety Research. Vol. 32 (2001) 237-252

15. Gardner D, Carlopio J, Fonteyn P, Cross J. Mechanical Equipment Injuries in Small Manufacturing Businesses. Knowledge, Behavioral, and Management Issues. International Journal of Occupational Safety and Ergonomics. Vol.5, No.1, 59-71. 1999.

16. Bimonte A. Win Empowered Workers' Commitment to Exceeding Basic Safety Compliance. Occupational Health & Safety. Vol. 63, No. 5. May, 1994.

17. Sulzer-Azaroff, B Harris, T McCann, K. Beyond Training: Organizational Performance Management Techniques. Occupational Medicine: State of the Art Reviews. Vol. 9, No. 2, April-June 1994.

18. Geller ES, Boyce TE, Williams JH et al. Researching Behavior-Based Safety: A Multi-Method Assessment and Evaluation. Proceedings of the 37th Annual Professional Development Conference and Exposition. Des Plaines, IL: American Society of Safety Engineers, 1998.

19. DePasquale J, Geller ES. Critical Success Factors for Behavior-Based Safety: A Study of Twenty Industry-Wide Applications. Journal of Safety Research. 30 (4), 237-249, 1999.

20. Gilmore MR, Perdue SR. Behavior-Based Safety: The Next Step in Injury Prevention. Proceedings of the Society of Petroleum Engineers International Conference. Kuala Lumpur, Malaysia: Society of Petroleum Engineers, Inc., March 2002.

21. Groover D, Hodson S. Behavior-Based Training for Safety & Health. Occupational Hazards. Vol. 60, Issue 9, 45-51, September 1998.

22. Roberts SD. Employees Forgot Their Hard Hats Again? Seven Lessons from Behavior Based Safety for Increasing PPE Use. Safety and Health. October, 2000.

23. Cooper D. Behavioural Safety: A Case Study from ICI Autocolors, Stowmarket. Available at http://www.behavioral-safety.com. Accessed August, 2002.

24. Valadez S, Williams JH, Roberts S. Employee-Driven Behavioral Change Improves Safety. People, Land, and Water. July/August, 1999.

25. Vojtecky M, Schmitz, M. Program Evaluation and Health and Safety Training. Journal of Safety Research. Vol. 17, No. 2, pp. 57-83. 1986.

26. Krause TR. Continuous Safety Progress Focuses on "Upstream" Factors in Analyses. Occupational Health & Safety. Vol.63, No. 10 , October 1994.

27. Sheff, R. Breakthrough Approaches to Reducing Medical Errors: A New Way of Thinking. Presented at CME conference for Tampa General Hospital; January 28, 2003; Tampa, Florida.

Bibliography

Geller ES. Behavior-Based Safety: Confusion, Controversy, and Clarification. Occupational Health and Safety. 68 (1), 40-49, 1999.

Geller ES, Krueger B, French A et al. The Human Factor. Utility Safety. April 2000.

Marsh T. Behavioural Safety – The Current Position. Training Solutions. Issue 9, summer 1999.

Olson DK, Gerberich SG. Traumatic Amputations in the Workplace. Journal of Occupational Medicine. 28(7): 480-5, 1986 July.

Owens S. BAPP Safety Builds Improved Organization Functioning. Perspectives in Performance Improvement. April, 2002, 11-14.

Sorock GS, Smith E, Hall N. Hospitalized Occupational Finger Amputations, New Jersey, 1985 and 1986. Amer J Ind Med. 23(3): 439–47, 1993 March.

Williams JH, Geller ES. Behavior-Based Intervention for Occupational Safety: Critical Impact of Social Comparison Feedback. Journal of Safety Research.

Appendices

Appendix A: SAS Program

```
libname bob'A:\';
proc import out = bob.eve
datafile = "A:\eve.xls"
dbms = excel2000 replace;
getnames = yes;
run;
proc print;
run;
proc freq;
tables jsa * amputation/ chisq;
run;
proc freq;
tables elim * amputation/ chisq;
run;
proc freq;
tables train * amputation/ chisq;
run;
proc freq;
tables behave * amputation/ chisq;
run;
proc freq;
tables oshalog * amputation/ chisq;
run;
proc freq;
tables maint * amputation/ chisq;
run;
proc freq;
tables cult * amputation/ chisq;
run;
proc freq;
tables employee * amputation/ chisq;
run;
proc freq;
tables nearmiss * amputation/ chisq;
run;
proc freq;
tables engineer * amputation/ chisq;
run;
proc freq;
run;
proc sort data = bob.eve;
by amputation;
run;
proc freq;
by amputation;
run;
proc logistic;
class jsa elim train behave oshalog maint cult employee nearmiss
engineer;
model amputation =jsa elim train behave oshalog maint cult employee
nearmiss engineer;
run;
```

The FREQ Procedure

Table of jsa by amputation

jsa(jsa) Frequency, Percent, Row Pct, Col Pct	amputation(amputation) 0	1	Total
0	11 18.03 45.83 39.29	13 21.31 54.17 39.39	24 39.34
1	17 27.87 45.95 60.71	20 32.79 54.05 60.61	37 60.66
Total	28 45.90	33 54.10	61 100.00

Frequency Missing = 9

Statistics for Table of jsa by amputation

Statistic	DF	Value	Prob
Chi-Square	1	0.0001	0.9931
Likelihood Ratio Chi-Square	1	0.0001	0.9931
Continuity Adj. Chi-Square	1	0.0000	1.0000
Mantel-Haenszel Chi-Square	1	0.0001	0.9932
Phi Coefficient		-0.0011	
Contingency Coefficient		0.0011	
Cramer's V		-0.0011	

Fisher's Exact Test

Cell (1,1) Frequency (F)	11
Left-sided Pr <= F	0.6008
Right-sided Pr >= F	0.6063
Table Probability (P)	0.2071
Two-sided Pr <= P	1.0000

Effective Sample Size = 61
Frequency Missing = 9

WARNING: 13% of the data are missing.

Appendix A (Continued)

```
               The FREQ Procedure

           Table of elim by amputation

     elim(elim)     amputation(amputation)

     Frequency,
     Percent  ,
     Row Pct  ,
     Col Pct  ,       0,       1,  Total
     ffffffffˆffffffffˆffffffffˆ
            0 ,     16 ,     18 ,     34
              ,  26.23 ,  29.51 ,  55.74
              ,  47.06 ,  52.94 ,
              ,  57.14 ,  54.55 ,
     ffffffffˆffffffffˆffffffffˆ
            1 ,     12 ,     15 ,     27
              ,  19.67 ,  24.59 ,  44.26
              ,  44.44 ,  55.56 ,
              ,  42.86 ,  45.45 ,
     ffffffffˆffffffffˆffffffffˆ
     Total          28       33       61
                 45.90    54.10   100.00

             Frequency Missing = 9


               The FREQ Procedure

      Statistics for Table of elim by amputation

Statistic                     DF       Value      Prob
ffffffffffffffffffffffffffffffffffffffffffffffffffffff
Chi-Square                     1      0.0414    0.8387
Likelihood Ratio Chi-Square    1      0.0414    0.8387
Continuity Adj. Chi-Square     1      0.0000    1.0000
Mantel-Haenszel Chi-Square     1      0.0407    0.8400
Phi Coefficient                       0.0261
Contingency Coefficient               0.0260
Cramer's V                            0.0261


              Fisher's Exact Test
      ffffffffffffffffffffffffffffffffff
      Cell (1,1) Frequency (F)        16
      Left-sided Pr <= F          0.6776
      Right-sided Pr >= F         0.5223

      Table Probability (P)       0.1998
      Two-sided Pr <= P           1.0000

           Effective Sample Size = 61
             Frequency Missing = 9

     WARNING: 13% of the data are missing.
```

```
                The FREQ Procedure

           Table of train by amputation

    train(train)     amputation(amputation)

    Frequency,
    Percent  ,
    Row Pct  ,
    Col Pct  ,       0,       1,  Total
    ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
           0 ,     17 ,     15 ,     32
             ,  27.87 ,  24.59 ,  52.46
             ,  53.13 ,  46.88 ,
             ,  60.71 ,  45.45 ,
    ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
           1 ,     11 ,     18 ,     29
             ,  18.03 ,  29.51 ,  47.54
             ,  37.93 ,  62.07 ,
             ,  39.29 ,  54.55 ,
    ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
    Total          28       33       61
                45.90    54.10   100.00

           Frequency Missing = 9
```

The FREQ Procedure

Statistics for Table of train by amputation

Statistic	DF	Value	Prob
Chi-Square	1	1.4143	0.2343
Likelihood Ratio Chi-Square	1	1.4212	0.2332
Continuity Adj. Chi-Square	1	0.8686	0.3513
Mantel-Haenszel Chi-Square	1	1.3911	0.2382
Phi Coefficient		0.1523	
Contingency Coefficient		0.1505	
Cramer's V		0.1523	

Fisher's Exact Test

Cell (1,1) Frequency (F)	17
Left-sided Pr <= F	0.9263
Right-sided Pr >= F	0.1758
Table Probability (P)	0.1021
Two-sided Pr <= P	0.3058

Effective Sample Size = 61
Frequency Missing = 9

WARNING: 13% of the data are missing.

Appendix A (Continued)

The FREQ Procedure

Table of behave by amputation

```
behave(behave)
          amputation(amputation)

Frequency,
Percent  ,
Row Pct  ,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,      8 ,     16 ,     24
         ,  13.11 ,  26.23 ,  39.34
         ,  33.33 ,  66.67 ,
         ,  28.57 ,  48.48 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,     20 ,     17 ,     37
         ,  32.79 ,  27.87 ,  60.66
         ,  54.05 ,  45.95 ,
         ,  71.43 ,  51.52 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total          28       33       61
            45.90    54.10   100.00
```

Frequency Missing = 9

The FREQ Procedure

Statistics for Table of behave by amputation

Statistic	DF	Value	Prob
Chi-Square	1	2.5170	0.1126
Likelihood Ratio Chi-Square	1	2.5516	0.1102
Continuity Adj. Chi-Square	1	1.7517	0.1857
Mantel-Haenszel Chi-Square	1	2.4757	0.1156
Phi Coefficient		-0.2031	
Contingency Coefficient		0.1991	
Cramer's V		-0.2031	

Fisher's Exact Test

Cell (1,1) Frequency (F)	8
Left-sided Pr <= F	0.0924
Right-sided Pr >= F	0.9686
Table Probability (P)	0.0610
Two-sided Pr <= P	0.1256

Effective Sample Size = 61
Frequency Missing = 9

WARNING: 13% of the data are missing.

Appendix A (Continued)

The FREQ Procedure

Table of oshalog by amputation

oshalog(oshalog)
amputation(amputation)

Frequency / Percent / Row Pct / Col Pct	0	1	Total
0	13 21.31 34.21 46.43	25 40.98 65.79 75.76	38 62.30
1	15 24.59 65.22 53.57	8 13.11 34.78 24.24	23 37.70
Total	28 45.90	33 54.10	61 100.00

Frequency Missing = 9

The FREQ Procedure

Statistics for Table of oshalog by amputation

Statistic	DF	Value	Prob
Chi-Square	1	5.5473	0.0185
Likelihood Ratio Chi-Square	1	5.6094	0.0179
Continuity Adj. Chi-Square	1	4.3689	0.0366
Mantel-Haenszel Chi-Square	1	5.4564	0.0195
Phi Coefficient		-0.3016	
Contingency Coefficient		0.2887	
Cramer's V		-0.3016	

Fisher's Exact Test

Cell (1,1) Frequency (F)	13
Left-sided Pr <= F	0.0180
Right-sided Pr >= F	0.9958
Table Probability (P)	0.0138
Two-sided Pr <= P	0.0330

Effective Sample Size = 61
Frequency Missing = 9

WARNING: 13% of the data are missing.

The FREQ Procedure

Table of maint by amputation

```
maint(maint)     amputation(amputation)

Frequency,
Percent  ,
Row Pct  ,
Col Pct  ,       0,       1,  Total
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       0 ,      9 ,     14 ,     23
         ,  14.75 ,  22.95 ,  37.70
         ,  39.13 ,  60.87 ,
         ,  32.14 ,  42.42 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
       1 ,     19 ,     19 ,     38
         ,  31.15 ,  31.15 ,  62.30
         ,  50.00 ,  50.00 ,
         ,  67.86 ,  57.58 ,
ƒƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆƒƒƒƒƒƒƒƒˆ
Total          28       33       61
            45.90    54.10   100.00
```

Frequency Missing = 9

The FREQ Procedure

Statistics for Table of maint by amputation

Statistic	DF	Value	Prob
Chi-Square	1	0.6817	0.4090
Likelihood Ratio Chi-Square	1	0.6854	0.4077
Continuity Adj. Chi-Square	1	0.3142	0.5751
Mantel-Haenszel Chi-Square	1	0.6705	0.4129
Phi Coefficient		-0.1057	
Contingency Coefficient		0.1051	
Cramer's V		-0.1057	

Fisher's Exact Test

Cell (1,1) Frequency (F)	9
Left-sided Pr <= F	0.2883
Right-sided Pr >= F	0.8624
Table Probability (P)	0.1507
Two-sided Pr <= P	0.4398

Effective Sample Size = 61
Frequency Missing = 9

WARNING: 13% of the data are missing.

Appendix A (Continued)

The FREQ Procedure

Table of cult by amputation

cult(cult) Frequency / Percent / Row Pct / Col Pct	amputation(amputation) 0	1	Total
0	17	21	38
	27.87	34.43	62.30
	44.74	55.26	
	60.71	63.64	
1	11	12	23
	18.03	19.67	37.70
	47.83	52.17	
	39.29	36.36	
Total	28	33	61
	45.90	54.10	100.00

Frequency Missing = 9

The FREQ Procedure

Statistics for Table of cult by amputation

Statistic	DF	Value	Prob
Chi-Square	1	0.0551	0.8145
Likelihood Ratio Chi-Square	1	0.0550	0.8145
Continuity Adj. Chi-Square	1	0.0000	1.0000
Mantel-Haenszel Chi-Square	1	0.0542	0.8160
Phi Coefficient		-0.0300	
Contingency Coefficient		0.0300	
Cramer's V		-0.0300	

Fisher's Exact Test

Cell (1,1) Frequency (F)	17
Left-sided Pr <= F	0.5114
Right-sided Pr >= F	0.6916
Table Probability (P)	0.2030
Two-sided Pr <= P	1.0000

Effective Sample Size = 61
Frequency Missing = 9

WARNING: 13% of the data are missing.

The FREQ Procedure

Table of employee by amputation

employee(employee) amputation(amputation)

Frequency / Percent / Row Pct / Col Pct	0	1	Total
0	10 16.39 37.04 35.71	17 27.87 62.96 51.52	27 44.26
1	18 29.51 52.94 64.29	16 26.23 47.06 48.48	34 55.74
Total	28 45.90	33 54.10	61 100.00

Frequency Missing = 9

The FREQ Procedure

Statistics for Table of employee by amputation

Statistic	DF	Value	Prob
Chi-Square	1	1.5329	0.2157
Likelihood Ratio Chi-Square	1	1.5431	0.2142
Continuity Adj. Chi-Square	1	0.9594	0.3273
Mantel-Haenszel Chi-Square	1	1.5078	0.2195
Phi Coefficient		-0.1585	
Contingency Coefficient		0.1566	
Cramer's V		-0.1585	

Fisher's Exact Test

Cell (1,1) Frequency (F)	10
Left-sided Pr <= F	0.1637
Right-sided Pr >= F	0.9332
Table Probability (P)	0.0970
Two-sided Pr <= P	0.3017

Effective Sample Size = 61
Frequency Missing = 9

WARNING: 13% of the data are missing.

```
                The FREQ Procedure

        Table of nearmiss by amputation

      nearmiss(nearmiss)
                amputation(amputation)

      Frequency,
      Percent  ,
      Row Pct  ,
      Col Pct  ,       0,       1,  Total
      fffffffffˆffffffffˆffffffffˆ
             0 ,     16 ,     20 ,     36
               ,  26.23 ,  32.79 ,  59.02
               ,  44.44 ,  55.56 ,
               ,  57.14 ,  60.61 ,
      fffffffffˆffffffffˆffffffffˆ
             1 ,     12 ,     13 ,     25
               ,  19.67 ,  21.31 ,  40.98
               ,  48.00 ,  52.00 ,
               ,  42.86 ,  39.39 ,
      fffffffffˆffffffffˆffffffffˆ
      Total          28       33       61
                  45.90    54.10   100.00

             Frequency Missing = 9


                The FREQ Procedure

     Statistics for Table of nearmiss by amputation

Statistic                     DF       Value      Prob
ffffffffffffffffffffffffffffffffffffffffffffffffffffff
Chi-Square                     1      0.0751    0.7840
Likelihood Ratio Chi-Square    1      0.0751    0.7841
Continuity Adj. Chi-Square     1      0.0002    0.9897
Mantel-Haenszel Chi-Square     1      0.0739    0.7858
Phi Coefficient                      -0.0351
Contingency Coefficient               0.0351
Cramer's V                           -0.0351


               Fisher's Exact Test
       ffffffffffffffffffffffffffffffffff
       Cell (1,1) Frequency (F)        16
       Left-sided Pr <= F          0.4944
       Right-sided Pr >= F         0.7039

       Table Probability (P)       0.1982
       Two-sided Pr <= P           0.8001

            Effective Sample Size = 61
              Frequency Missing = 9

      WARNING: 13% of the data are missing.
```

```
                The FREQ Procedure

         Table of engineer by amputation

       engineer(engineer)
                 amputation(amputation)

       Frequency,
       Percent  ,
       Row Pct  ,
       Col Pct  ,       0,       1,  Total
       ffffffffff^ffffffff^ffffffff^
              0 ,     13 ,     15 ,     28
                ,  21.31 ,  24.59 ,  45.90
                ,  46.43 ,  53.57 ,
                ,  46.43 ,  45.45 ,
       ffffffffff^ffffffff^ffffffff^
              1 ,     15 ,     18 ,     33
                ,  24.59 ,  29.51 ,  54.10
                ,  45.45 ,  54.55 ,
                ,  53.57 ,  54.55 ,
       ffffffffff^ffffffff^ffffffff^
       Total          28       33       61
                   45.90    54.10   100.00

             Frequency Missing = 9


                The FREQ Procedure

    Statistics for Table of engineer by amputation

Statistic                     DF       Value      Prob
ffffffffffffffffffffffffffffffffffffffffffffffffffffff
Chi-Square                     1      0.0058    0.9394
Likelihood Ratio Chi-Square    1      0.0058    0.9394
Continuity Adj. Chi-Square     1      0.0000    1.0000
Mantel-Haenszel Chi-Square     1      0.0057    0.9399
Phi Coefficient                       0.0097
Contingency Coefficient               0.0097
Cramer's V                            0.0097


               Fisher's Exact Test
        ffffffffffffffffffffffffffffffffff
        Cell (1,1) Frequency (F)        13
        Left-sided Pr <= F          0.6308
        Right-sided Pr >= F         0.5718

        Table Probability (P)       0.2025
        Two-sided Pr <= P           1.0000

            Effective Sample Size = 61
              Frequency Missing = 9

       WARNING: 13% of the data are missing.
```

The FREQ Procedure

SIC

SIC	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	10	14.29	10	14.29
aff	1	1.43	11	15.71
con	6	8.57	17	24.29
finance	2	2.86	19	27.14
hrman	5	7.14	24	34.29
man	10	14.29	34	48.57
pub	3	4.29	37	52.86
rtrade	7	10.00	44	62.86
serv	18	25.71	62	88.57
trans	3	4.29	65	92.86
wstrade	5	7.14	70	100.00

F2

F2	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	62	88.57	62	88.57
1	8	11.43	70	100.00

F3

F3	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	66	94.29	66	94.29
1	4	5.71	70	100.00

F4

F4	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	65	92.86	65	92.86
1	5	7.14	70	100.00

The FREQ Procedure

jsa

jsa	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	24	39.34	24	39.34
1	37	60.66	61	100.00

Frequency Missing = 9

elim

elim	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	34	55.74	34	55.74
1	27	44.26	61	100.00

Frequency Missing = 9

train

train	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	32	52.46	32	52.46
1	29	47.54	61	100.00

Frequency Missing = 9

behave

behave	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	24	39.34	24	39.34
1	37	60.66	61	100.00

Frequency Missing = 9

oshalog

oshalog	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	38	62.30	38	62.30
1	23	37.70	61	100.00

Frequency Missing = 9

maint

maint	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	23	37.70	23	37.70
1	38	62.30	61	100.00

Frequency Missing = 9

cult

cult	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	38	62.30	38	62.30
1	23	37.70	61	100.00

Frequency Missing = 9

employee

employee	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	27	44.26	27	44.26
1	34	55.74	61	100.00

Frequency Missing = 9

nearmiss

nearmiss	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	36	59.02	36	59.02
1	25	40.98	61	100.00

Frequency Missing = 9

engineer

engineer	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	28	45.90	28	45.90
1	33	54.10	61	100.00

Frequency Missing = 9

Appendix A (Continued)

change

change	Frequency	Percent	Cumulative Frequency	Cumulative Percent
na	55	78.57	55	78.57
no	8	11.43	63	90.00
yes	7	10.00	70	100.00

freqtrain

freqtrain	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	62	100.00	62	100.00

Frequency Missing = 8

anyform

anyform	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	63	100.00	63	100.00

Frequency Missing = 7

committee

committee	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	63	100.00	63	100.00

Frequency Missing = 7

other

other	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	63	100.00	63	100.00

Frequency Missing = 7

amputation

amputation	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	35	50.00	35	50.00
1	35	50.00	70	100.00

Appendix A (Continued)

--------------------------------------- amputation=0 ---------------------------------

The FREQ Procedure

SIC

SIC	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	4	11.43	4	11.43
con	2	5.71	6	17.14
finance	1	2.86	7	20.00
hrman	1	2.86	8	22.86
man	3	8.57	11	31.43
pub	3	8.57	14	40.00
rtrade	4	11.43	18	51.43
serv	13	37.14	31	88.57
trans	2	5.71	33	94.29
wstrade	2	5.71	35	100.00

F2

F2	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	35	100.00	35	100.00

F3

F3	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	35	100.00	35	100.00

F4

F4	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	35	100.00	35	100.00

--------------------------------------- amputation=0 ----------------------------------

The FREQ Procedure

jsa

jsa	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	11	39.29	11	39.29
1	17	60.71	28	100.00

Frequency Missing = 7

elim

elim	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	16	57.14	16	57.14
1	12	42.86	28	100.00

Frequency Missing = 7

train

train	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	17	60.71	17	60.71
1	11	39.29	28	100.00

Frequency Missing = 7

behave

behave	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	8	28.57	8	28.57
1	20	71.43	28	100.00

Frequency Missing = 7

oshalog

oshalog	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	13	46.43	13	46.43
1	15	53.57	28	100.00

Frequency Missing = 7

maint

maint	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	9	32.14	9	32.14
1	19	67.86	28	100.00

Frequency Missing = 7

Appendix A (Continued)

cult

cult	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	17	60.71	17	60.71
1	11	39.29	28	100.00

Frequency Missing = 7

employee

employee	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	10	35.71	10	35.71
1	18	64.29	28	100.00

Frequency Missing = 7

nearmiss

nearmiss	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	16	57.14	16	57.14
1	12	42.86	28	100.00

Frequency Missing = 7

engineer

engineer	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	13	46.43	13	46.43
1	15	53.57	28	100.00

Frequency Missing = 7

change

change	Frequency	Percent	Cumulative Frequency	Cumulative Percent
na	35	100.00	35	100.00

freqtrain

freqtrain	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	34	100.00	34	100.00

Frequency Missing = 1

anyform

anyform	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	35	100.00	35	100.00

committee

committee	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	35	100.00	35	100.00

other

other	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	35	100.00	35	100.00

--------------------------------------- amputation=1 ---------------------------------

The FREQ Procedure

SIC

SIC	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	6	17.14	6	17.14
aff	1	2.86	7	20.00
con	4	11.43	11	31.43
finance	1	2.86	12	34.29
hrman	4	11.43	16	45.71
man	7	20.00	23	65.71
rtrade	3	8.57	26	74.29
serv	5	14.29	31	88.57
trans	1	2.86	32	91.43
wstrade	3	8.57	35	100.00

F2

F2	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	27	77.14	27	77.14
1	8	22.86	35	100.00

F3

F3	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	31	88.57	31	88.57
1	4	11.43	35	100.00

F4

F4	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	30	85.71	30	85.71
1	5	14.29	35	100.00

Appendix A (Continued)

-- amputation=1 ----------------------------------

The FREQ Procedure

jsa

jsa	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	13	39.39	13	39.39
1	20	60.61	33	100.00

Frequency Missing = 2

elim

elim	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	18	54.55	18	54.55
1	15	45.45	33	100.00

Frequency Missing = 2

train

train	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	15	45.45	15	45.45
1	18	54.55	33	100.00

Frequency Missing = 2

behave

behave	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	16	48.48	16	48.48
1	17	51.52	33	100.00

Frequency Missing = 2

oshalog

oshalog	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	25	75.76	25	75.76
1	8	24.24	33	100.00

Frequency Missing = 2

maint

maint	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	14	42.42	14	42.42
1	19	57.58	33	100.00

Frequency Missing = 2

cult

cult	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	21	63.64	21	63.64
1	12	36.36	33	100.00

Frequency Missing = 2

employee

employee	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	17	51.52	17	51.52
1	16	48.48	33	100.00

Frequency Missing = 2

nearmiss

nearmiss	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	20	60.61	20	60.61
1	13	39.39	33	100.00

Frequency Missing = 2

engineer

engineer	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	15	45.45	15	45.45
1	18	54.55	33	100.00

Frequency Missing = 2

Appendix A (Continued)

change

change	Frequency	Percent	Cumulative Frequency	Cumulative Percent
na	20	57.14	20	57.14
no	8	22.86	28	80.00
yes	7	20.00	35	100.00

freqtrain

freqtrain	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	28	100.00	28	100.00

Frequency Missing = 7

anyform

anyform	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	28	100.00	28	100.00

Frequency Missing = 7

committee

committee	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	28	100.00	28	100.00

Frequency Missing = 7

other

other	Frequency	Percent	Cumulative Frequency	Cumulative Percent
.	28	100.00	28	100.00

Frequency Missing = 7

The LOGISTIC Procedure

Model Information

Data Set	BOB.EVE	
Response Variable	amputation	amputation
Number of Response Levels	2	
Number of Observations	61	
Model	binary logit	
Optimization Technique	Fisher's scoring	

Response Profile

Ordered Value	amputation	Total Frequency
1	0	28
2	1	33

Probability modeled is amputation=0.

NOTE: 9 observations were deleted due to missing values for the response or explanatory variables.

Class Level Information

Class	Value	Design Variables 1
jsa	0	1
	1	-1
elim	0	1
	1	-1
train	0	1
	1	-1
behave	0	1
	1	-1
oshalog	0	1
	1	-1
maint	0	1
	1	-1
cult	0	1
	1	-1
employee	0	1
	1	-1
nearmiss	0	1
	1	-1
engineer	0	1
	1	-1

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	86.154	96.122
SC	88.265	119.342
-2 Log L	84.154	74.122

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	10.0315	10	0.4377
Score	9.4158	10	0.4931
Wald	8.2151	10	0.6078

Type III Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
jsa	1	0.0538	0.8166
elim	1	0.0071	0.9327
train	1	1.8048	0.1791
Behave	1	0.7107	0.3992
oshalog	1	2.7155	0.0994
maint	1	0.7874	0.3749
cult	1	0.0028	0.9581
employee	1	1.0308	0.3100
nearmiss	1	0.2285	0.6327
engineer	1	0.2543	0.6141

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-0.2894	0.3614	0.6411	0.4233
jsa	0	1	-0.0853	0.3677	0.0538	0.8166
elim	0	1	0.0288	0.3407	0.0071	0.9327
train	0	1	0.4399	0.3275	1.8048	0.1791
behave	0	1	-0.2723	0.3230	0.7107	0.3992
oshalog	0	1	-0.5279	0.3204	2.7155	0.0994
maint	0	1	-0.3094	0.3486	0.7874	0.3749
cult	0	1	0.0168	0.3209	0.0028	0.9581
employee	0	1	-0.3228	0.3180	1.0308	0.3100
nearmiss	0	1	0.1632	0.3414	0.2285	0.6327
engineer	0	1	0.1843	0.3654	0.2543	0.6141

Appendix A (Continued)

Odds Ratio Estimates

Effect		Point Estimate	95% Wald Confidence Limits	
jsa	0 vs 1	0.843	0.200	3.563
elim	0 vs 1	1.059	0.279	4.027
train	0 vs 1	2.411	0.668	8.701
behave	0 vs 1	0.580	0.164	2.058
oshalog	0 vs 1	0.348	0.099	1.221
maint	0 vs 1	0.539	0.137	2.113
cult	0 vs 1	1.034	0.294	3.638
employee	0 vs 1	0.524	0.151	1.824
nearmiss	0 vs 1	1.386	0.364	5.283
engineer	0 vs 1	1.446	0.345	6.055

The LOGISTIC Procedure

Association of Predicted Probabilities and Observed Responses

Percent Concordant	70.7	Somers' D	0.425
Percent Discordant	28.1	Gamma	0.430
Percent Tied	1.2	Tau-a	0.215
Pairs	924	c	