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The Effectiveness of the Behavior-Based Safety Program at Jacobs Sverdrup's NASA Langley Rome Contract

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THE EFFECTIVENESS OF THE BEHAVIOR-BASED SAFETY PROGRAM AT JACOBS SVERDRUP'S NASA LANGELY ROME CONTRACT

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INTRODUCTION

The training market offers a wide variety of safety programs. Safety has become an important issue for corporations. With work place accident costs rising into the thousands of dollars, companies are now taking a closer look into safety. Safety incidents do not just cost the company medical bills and damaged equipment costs; they include insurance premiums increases, production decreases, and lose of customers due to poor safety records.

Behavior-based safety is one of the newest safety programs to be marketed. This safety program uses psychology and employee ownership to prevent safety incidents. Behavior-based safety sets up a program that uses a safety committee that is made up of employees. They use behavior-based safety observations to determine the most prevalent at-risk behaviors. The observations use negative and positive reinforcement to help modify employee behaviors, supporting the behaviors that are good and acknowledging those that place the employee at risk of having a safety incident. The employees are trained and then asked to do observations on other employees while they are working. These observations are then compiled into a database that allows the committee to make decisions on where more training needs to be utilized or employee awareness needs to be heightened.

STATEMENT OF PROBLEM

The problem of this study was to determine if the implementation of the behavior-based safety program at the ROME contract NASA Langley Research Center lowered the amount of safety incidents.

RESEARCH HYPOTHESIS

To guide this problem, the following hypothesis was established:

H_1: There was a direct correlation between the number of behavior based safety observations performed and safety incident rates of the employees under the ROME contract.

BACKGROUND AND SIGNIFIGANCE

According to a 1998 U.S Department of Health and Human Services report, 16 workers are killed and 36,000 are injured on a daily basis (1998). These injuries are harmful to the employees, the employee's families, and the employer. The employee faces the loss of income during the recovery period. Workman's Composition claims take time filling and yet the employee's still is faced with bills. The employee's family faces the drama of having the employee immobilized during the recovery time or in the worst case scenario, loss of the employee due to death. The employer faces rising insurance costs, health care premiums, workman's compensation premiums, training costs, temporary labor costs, and reduced productions costs. "Miller (1997) estimated that every year U.S. employers pay approximately $200 billion in direct costs associated with injuries that occur both on and off the job" (DePasquale & Geller, 1999, p. 238). The direct costs are but a fraction of the real costs that an employer faces when the indirect costs are considered. Indirect costs are those costs that are not directly seen. Production loss from decreased employee moral, the time lost while investigating the injury, the companies reputation, contracts lost due to a poor safety record, time for training a temporary replacement for the injured employee, and covering the injured

employees shift are but a few of the indirect costs that a company faces following an occupational injury or death.

Since the establishment of the Occupational Safety and Health Administration (OSHA) in 1971, safety professionals have developed a variety of safety programs and methods to reduce the number of occupational injuries and deaths. The latest safety program is labeled as behavior based safety. "Behavior-based safety can be defined as the application of principles and methods derived from the field of applied behavior analysis to industrial safety. Based on 40 years of rigorous research and hard science, these principles included rewarding feedback and positive reinforcement to increase appropriate behaviors and corrective feedback to decrease improper behaviors" (Blair, 1999). Research has proven that behavior-based safety can reduce work place injuries (Geller, 1999), but there is little to no research on the correlation of the number of incidents compared to the amount of safety observations.

LIMITATIONS

The limitations of the study were as follows:

1. The results of the study were limited to the ROME employees at NASA Langley Research Center.
2. The study relied on the number of behavior-based safety observations performed by ROME employees.
3. Participation in the behavior-based safety observation process was on a voluntary basis for all ROME employees.
4. Safety incidents and safety observations were tracked over a one year time period starting with the first behavior-based safety observations.

5. The safety incident rate from the year prior to the start of the study will be used as a baseline.

ASSUMPTIONS

The assumptions that were assumed to be true and correct were as follows:

1. Employee participation in behavior-based safety observations was voluntary.
2. All employees under the ROME contract were included in the study.
3. Employees were trained in the behavior-based safety program prior to performing observations.

PROCEDURES

A behavior-based safety program was introduced to the personnel on the ROME contract at NASA Langley Research Center. An initial group of personnel were trained on setting up the behavior-based safety program. This training included setting up the behavior-based safety committee, using the data collected to set up intervention methods to improve safety, the psychology used to improve employee behaviors, and performing behavior based observations. The initial group of people trained formed the behavior-based safety committee. Training was then given to all employees that were going to be safety observers. The observer training included training on the basic concept of behavior-based safety and how to perform behavior-based safety observations. The number of observations performed over a one year period was tracked by month starting with the first observation. The amount of safety incidents were tracked over a two year period, one year prior to the implementation of the behavior based safety observations and one year following the implementation of the behavior based safety observations. The total observations for each month were compared to the number of safety incidents

for that month. Then they were checked against the baseline established from the number of safety incidents that occurred in that month during previous year. These observations and incidents were tabulated and compared by progress per year to determine if behavior-based safety reduced the number of incidents.

DEFINITION OF TERMS

The following is a list of terms and definitions used to assist the reader of this study:

Behavior-based safety (BBS) - A systematic development of safety behaviors through the use of behavior psychology and employee involvement. The process consists of training observers, setting up an employee-based committee to analyze data, setting up an observation checklist, collecting data from observations, and focusing attention on correcting at risk behaviors identified as the most prevalent issues from the data collection.

Behavior-based safety observation (BBSOR) - A formal process where a trained observer, using a pre-made check list, observes an employee while working for a time frame of about ten minutes. The observation is to identify safe and at risk behaviors identified by using a check list. Following the observations the observer reviews the findings with the employee and then enters the data into a database.

E-1- An E-1 is an Employer's First Report of Injury. It is required by the applicable State where a compensable work related injury or illness occurs and one of the following takes place:

- Employee requires a doctor or medical clinic visit as a result of a job related illness or injury or alleged job related illness or injury.
- The doctor or medical clinic visit generates a medical bill.
- An employee asks to file a workers compensation claim (Lindstrom & Miller, 2003, p. 1)

Observation- Behavior-based safety observation.

OSHA- Occupational Safety & Health Administration.

OSHA Recordable- An occupational injury that "results in any of the following: death, days away from work, restricted work or transfer to another job, medical treatment beyond first aid, or loss of consciousness. You must also consider a case to meet the general recording criteria if it involves a significant injury or illness diagnosed by a physician or other licensed health care professional, even if it does not result in death, days away from work, restricted work or job transfer, medical treatment beyond first aid, or loss of consciousness" (Code of Federal Regulations 29 CFR 1904.7).

ROME- (Research, Operations, Maintenance, and Engineering). ROME is the current contract awarded to Jacobs Sverdrup at NASA Langley. This contract covers over 300 employees functioning in the following departments: Research, Operations, Maintenance, and Engineering.

JS- Jacobs Sverdrup.

Safety incident- Any occupational injury, illness, or death that meets the requirements of an OSHA recordable or the JS definition of an E-1 rating.

OVERVIEW OF CHAPTERS

In Chapter I the need for lowering occupational injuries, illnesses, and deaths was introduced. Behavior-based safety was established as a viable tool for employers to use to lower safety incidents. The correlation between the number of behavior-based safety observations and the safety incident rate was the subject of this study.

Chapter II, Review of Literature, will support the need to lower safety incidents, establish behavior-based safety programs as an effective tool to lower safety incidents,

and support the need to investigate the relationship between observations and incidents. Chapter III, Methods and Procedures, will review the methods and techniques of data collection. Chapter IV, Findings, will present the analysis of the data. Chapter V, Summary, Conclusion, and Recommendations, will provide a summary of the research process, the confirmation or rejection of the hypothesis, and a projection of what the research findings mean to future needs of safety systems.

CHAPTER II

REVIEW OF LITERATURE

Behavior-based safety emerged from several well documented and used fields of study outside of safety. Processes from total quality management, organizational development principles, the field of psychology in applied behavior analysis, and safety practices are all combined into one conglomerate to form what is termed as behavior-based safety. The overall goal of this movement is to lower safety incidents and work place injuries. By combining safety with processes that have already been tried and proven techniques to modify behavior and improve quality, it is not surprising that there are positive results reported in today's journals and safety magazines. In fact, Sulzer-Azaroff and Austin (2000) reported reduction in injuries from 32 of 33 studies reviewed. Krause, Seymour, and Sloat (1998) provided a five year evaluation of a behavior-based method for improving safety performance of 73 companies which reported significant reductions in injuries in all of the sites. Nielsen and Austin (2005) report that the behavioral approach has been used in various occupational settings including roofing, paper mills, soft drink bottling, delivery drivers, electronic components facility, open-pit mines, and hospital emergency rooms. Behavior-based safety has become recognized for its ability to lower safety incidents. This chapter will review literature regarding behavior-based safety observations and incident reporting.

BEHAVIOR-BASED SAFETY OBSERVATIONS

Behavior-based safety observations are an integral part of the behavior-based safety process. Total quality management is an avid example of where behavior-based

safety uses methods that have been successful in areas other than safety. Total quality management uses a process where employees trained as quality inspectors use a predetermined checklist that outlines the procedures that should be followed by workers when performing a given task. This process was used to improve the quality of work done by promoting a standardized process that had been proven to yield quality products. This method of using workers to inspect other workers using a predetermined checklist was adopted into the behavior-based safety process. Behavior-based safety uses employees with predetermined checklists to observe other employees safety behaviors to identify safe and at-risk behaviors.

The statistical data received from the observations offer multiple benefits. The data can be used to focus attention and customize training on the behaviors that are putting employees most at-risk of being injured. The data can also be combined with that gathered from safety incident investigations and used to formulate the checklist that will be used in the observation process. This allows the observations to be focused on the most significant safety related behaviors. Therefore, the behaviors that are currently placing the employees in harms way can be focused upon. Choosing the behaviors to be represented on the checklist is a key factor for the success of the behavior-based safety program. As noted in a research paper, “An intervention’s ultimate value can only be as good as the precise behaviors selected” (Sulzer-Azaroff & Austin, 2000, p. 20).

Once a customized behavior-based safety observation checklist has been developed, observers can start performing the behavior-based safety observations. During this process the observer goes to the location where work is being performed and asks if the employee performing the work would mind being observed. If the employee

allows the observation, the observer will watch the employee for a time period, usually about ten minutes. After the observation has been made the observer will step back from the work and use the checklist to document what was observed. At the end of the observation the observer will provide feedback to the employee about what was observed. This feedback portion of the observation is one of the most important steps; it allows the worker and the observer to discuss what if any at-risk behaviors were observed and how to prevent the at-risk behavior in the future.

The feedback portion of the behavior-based observation uses psychology called applied behavior analysis or reinforcement. B.F. Skinner developed the reinforcement theory in the 1930's and 1940's. "He discovered that whether a response to a stimulus continues to occur depends on the consequence that follows that behavior" (The History of Behaviorism, 2003, sect. 2, para. 2). The feedback portion includes use of both positive reinforcement and negative reinforcement. "Positive reinforcement is observed when a behavior is followed by a consequence that INCREASES the behavior's likelihood of reoccurring" (Reinforcment theory, 2005, sect. 2, para. 2). "Negative Reinforcement involves steps designed to lead one to appropriate action in order to escape or avoid an unwanted consequence. In other words, the desired behavior INCREASES with the use of negative reinforcement" (Reinforcment theory, 2005, sect. 2, para. 3). Both positive and negative reinforcements are used in the feedback process. When the observer notices safe behaviors during the observation, those behaviors will be praised during the feedback process. Likewise, if at-risk behavior is noticed during the observation, those behaviors will be discussed at the end of the feedback process. If any at-risk behaviors were noted during the observation, the observer should mention them

and then discuss a better method of doing the task that will eliminate the at-risk behavior and keep the employee safe.

SAFETY INCIDENTS

Safety incidents can include OSHA recordables, E-1s, vehicle accidents, first aids, and near misses, all of which can have a negative impact on the company. OSHA recordables are important since Federal law requires a reporting process be followed should an employee incur an injury on the job that meets the definition of a recordable injury. Should too many of these injuries be sustained a very unfriendly OSHA inspection will likely arise. E-1s are generally used by insurance companies. The tracking of this type of injury determines the rate an insurance company will require for workman compensation premiums. Vehicle accidents result in police reports and possible tickets along with increased insurance premiums and liability issues from law suites. First aid and near misses are the least costly of the safety incidents, but they still cost the company in the form of time spent tracking, documenting, and in indirect costs.

Incident tracking is done for several reasons. First, it is required by insurance companies and OSHA has some reporting requirements also. The information gathered from incident tracking also gives the employer data to find possible trends. Tracking the trends of the incidents can be bench marked against industry safety leaders to determine the health of a safety program. It can also be used to pinpoint certain unsafe behaviors or unsafe conditions that are prevailing root causes for the incidents. This can help employers focus attention on the aspects that will yield the highest results.

Unfortunately there currently are not many options to determine the health of a safety program other than the trailing metrics of safety such as incident rates. It is next to

impossible to determine all the actions that were taken to prevent getting injured on the job, or when a safety program successfully has changed unsafe behaviors. The current industry is asking for safety to be tracked using leading metrics that will help the employer prevent the injury prior to actually incurring a safety incident. The behavior-based safety observation is set up to help get this type of data. The data can be tabulated to show the employer the prevailing behaviors that are placing employees at-risk prior to incurring an incident. These leading metrics are of little use if not checked against the trailing metrics to ensure the intervention techniques utilized and the leading metrics collected are beneficial to the employer.

SUMMARY

This chapter discussed the components of behavior-based safety observations and safety incident tracking and the use of both to improve safety performance. Behavior-based safety observations were shown to have used aspects of total quality management and psychology in the form of applied behavior analysis. Safety incidents were discussed as a good tool to check safety performance. The consensus of the chapter is that when using both behavior-based safety observations and safety incidents rates an employer will have an effective tool to improve safety performance. Chapter III will discuss the methods and procedures of data collection used in this study.

CHAPTER III

METHODS AND PROCEEDURES

This chapter discusses the methods and procedures that were used in this study. It gives back ground information about the people who participated in the study while also looking at the process used to gather and analyze the data. This chapter is divided into eight subsections starting with this introduction and finishing with a summary. A description of the people who participated in the study will be discussed in the population section. The research variable section will discuss the variables measured and used in this study. The instrument design section looks deeper into the observation checklist. The procedures for providing an observation are covered in the field procedure section. The method of data collection section was used to show the procedure used to compile the data. The statistical analysis section covers the tools used to statistically evaluate the data that were received during the study. The summary is the last section and it will provide a brief overview of the content discussed in this chapter and will give preview of what is discussed in the next chapter.

POPULATION

Due to security and privacy issues the company's human resource department is unwilling to provide statistics on the current workforce under the contract. The information that is available suggests that the population size is at around 400 people. This group consists of a diverse group ranging from new employees to employees with over 20 years of service. The workforce is unique to standard companies in that many of the employees have worked on site for more years than the current contract. To provide fluidity of production the supervisors and shop personnel usually remain on site even

with contract changes. Usually the company under the old contract only retains upper management and lays off all of the other employees. These employees are then interviewed and hired by the company with the new contract. Therefore, even though the current contract is less than three years old a majority of the employees have been employed on center for far longer than that. Many of the employees have been through three different employers while working on center. This fact has given the company a work force of highly trained and specialized employees that knows the ins and outs of the day to day operations on center.

The employees employed by employers that are contracted under the ROME contract at NASA Langley Research Center will be participating in this research study. This includes four different employers and about 400 employees.

RESEARCH VARIABLES

The research study was an experimental study using two variables. The independent variable was behavior-based safety observations and the dependant variable is the E-1 incident rate. The experimenter chose to use the E-1 rate rather than the number of E-1s, since it gives a truer picture of the safety performance. An example would be two different divisions of a company reported three E-1s in the month of May. One division had worked an accumulative of 3,000 hours during May and the other accumulated 300,000 hours. The first division would have 1,000 hours per E-1 while the second division would have 100,000 hours per E-1. The results in this format give a better picture of the safety culture present in each division, by only listing the number of E-1s the divisions looked comparable.

INSTRUMENT USE

The goal of behavior-based safety is to prevent safety incidents by averting those behaviors that place the employees most at risk of having an accident. With this said, the behavior-based safety observation checklist needs to address the most prevalent issues that the employees are facing. The checklist is designed and made by the behavior-based safety committee. Since there are different jobs that have different hazards at this site and other sites for the company, the committee decided to reference what other segments had come up with, but customized its own observation checklist to fit the needs of this site. The committee reviewed previous accident reports and used surveys to determine what the most prevalent at-risk behaviors were on this site. The training received by the corporate safety office suggested this method for initiating a checklist. The training also suggested periodic updates to the checklist by analyzing the data gathered. The original observation checklist has not yet been updated and is shown in Appendix A.

FIELD PROCEEDURES

Once an employee went through behavior-based observer training, the employee was asked to participate in the process by performing observations weekly. The training was conducted by the corporate safety head of this region. The training was established as a requirement for employees to have prior to performing observations.

After the training is performed the observation process is covered in three steps: setting up the observation, the observation, and documenting the observation. Setting up the observation includes collecting material and finding the work. The first step in the observation process was to gather the material needed to perform the observation. This material included a pen or pencil, the behavior-based observation checklist (shown in

Appendix A), and any personal protective equipment (PPE) needed to protect the observer in the work area. The observer will then set up the observation by calling the shop supervisor to determine where employees are working. The goal is to prevent the accidents before they occur, therefore it does no good to observe employees on break or when they are not working. The next step is to go to the area where employees are working. It is critical that the observer waits for an opportune time to address the employee working. The goal is to not present more hazards to the employee by distracting them from their work. When a chance to address the employee presents itself, the observer must ask permission to perform the observation.

The observation step includes getting permission, the observation, and documenting the feedback. If permission is not given the observer cannot take offence but should just find someone else to observe. If permission is given the observer must step back to a safe location and far enough to prevent getting in the way of the work or presenting a hazard, but close enough to be able to observe the work. The observer is to observe the work for about ten minutes or until the task is through. The observer should never stop the worker unless the worker is taking a risk that could result in significant injury or death. Once the observation is completed the observer then uses the checklist to provide data on what was observed.

The final step is reviewing what was observed with the employee, sharing two-way feed back and reporting the data. In this step the observer will wait for an opportunity to talk with the employee that was observed. The ideal time should be when the employee finishes a step that will allow the employee to stop work for a review of the observation. The observer will then go over the form that was filled out with the

employee sharing the positive aspects first, followed by a discussion of the at-risk behaviors that were observed. The discussion should include suggestions of ways to mitigate the at-risk behaviors. After the observation is completed the form is checked for completeness and then turned in to the behavior-based safety committee for data tracking purposes.

METHODS OF DATA COLLECTION

The behavior-based safety committee collected the behavior-based observation checklists to use for trend analysis. The committee provided the data collected for this study. The data was then used to provide the number of behavior-based observations performed over the entire research period for each month from November, 2005, through October, 2006.

The Safety Manager provided the data for the dependant variable. The safety incidents are tracked at various levels for reporting purposes to the contract administrators, OSHA, and the corporate office for insurance purposes. The safety Manager approved the research study and provided the data required for the dependant variable.

This study used E-1s, as defined by the corporate safety manual, as the dependant variable. E-1s were tracked by month in the form of E-1s divided by the number of hours worked on the contract. This is called the E-1 rate. These data were collected from October, 2004, to October, 2005, to provide a baseline to compare to the data received during the research period. The data were then tracked from October, 2005, to October, 2006, for the actual experiment.

STATISTICAL ANALYSIS

To determine the relationship between the independent variable (behavior-based safety observations) and the dependant variable (safety incident rate) the mean, median, mode, Chi-square, and t-test were used for the statistical analysis.

SUMMARY

This chapter discussed the methods and procedures used for data collection and analysis during the study. The chapter was divided into eight subsections for easier dissemination of the information provided. The population section gave a background description of the people who were participating in the experiment. The research variables were named and discussed in the next section. The instrument design section examined how the observation checklist was established and the field procedure section established the procedures used during the observation process. The method of data collection section was used to show the procedure used to compile the data, and the statistical analysis section discussed the tools used to statistically evaluate the data.

Chapter IV will be used to discuss the findings of the research study. In this chapter the data will be tabolized, and statistical analysis will be used to examine the results.

CHAPTER IV

FINDINGS

The problem of this study was to determine if the implementation of the behavior-based safety program at the ROME contract NASA Langley Research Center lowered the amount of safety incidents. This chapter contains two sections: the findings of the research and a brief summary of the findings. The findings section was used to review the data collected and the statistical analysis that will be used in Chapter V to support or reject the hypothesis of the problem statement. The summary section provides a brief summary of the data and statistical analysis covered in this chapter.

FINDINGS

The behavior-based safety program was implemented in November of 2005. The E-1 data were collected from November, 2004, to the end of October, 2006, for comparison of the year prior to the program and the year of the program. The number of observations performed was also tracked from November, 2005, through the end of October, 2006, for use in the statistical analysis.

The data collected for November, 2004, through October, 2005, reported having a total of 637,091 work hours and a total of 12 E-1s. Statistical analysis show the mean number of E-1s was 1 with a median of 1. The E-1 rate for the year was calculated to be 53,091. The presentation of data appears in Table 1.

The data collected from November, 2005, through October, 2006, appears on Table 2. The data for this year were reported having a total of 595,652 hours worked, with one E-1 and an E-1 rate of 595,652 hours worked per E-1. Statistical analysis performed showed the mean number of E-1s was 0.0833.

TABLE 1
2004-2005 Safety Incident Rate Data

Month	Hours Worked	# of E-1s	# of Observations	E-1 Rate/month
Nov-04	52,935.0	1	0	52935
Dec-04	75,258.0	0	0	0
Jan-05	54,813.0	0	0	0
Feb-05	70,153.0	0	0	0
Mar-05	60,602.0	1	0	60602
Apr-05	45,748.0	3	0	15249.33333
May-05	46,027.0	0	0	0
Jun-05	57,043.0	2	0	28521.5
Jul-05	39,449.0	2	0	19724.5
Aug-05	42,105.0	0	0	0
Sep-05	51,433.0	2	0	25716.5
Oct-05	41,525.0	1	0	41525
Year End Totals	637,091	12	0	53090.91667

E-1 Rate= hours worked /the Number of E-1s		**04-05 E-1 rate =**	**637,091 / 12**
Mean E-1	1.0000		
Median E-1	1	**04-05 E-1 rate =**	**53090.91667**
Mode E-1	0		

TABLE 2
2005-2006 Safety Incident Rate and Observation Data

Month	Hours Worked	# of E-1s	# of Observations	E-1 Rate/month
Nov-05	36,540.0	0	28	0
Dec-05	51,132.0	0	36	0
Jan-06	40,661.0	0	64	0
Feb-06	44,311.0	0	50	0
Mar-06	56,539.0	0	71	0
Apr-06	48,481.0	0	90	0
May-06	48,923.0	0	78	0
Jun-06	60,713.0	1	57	60713
Jul-06	47,061.0	0	61	0
Aug-06	51,390.0	0	87	0
Sep-06	59,975.0	0	130	0
Oct-06	49,926.0	0	161	0
Year End Totals	595,652	1	913	595652

E-1 Rate= hours worked /the Number of E-1s		**04-05 E-1 rate =**	**595,652 / 1**
Mean E-1	0.0833		
Median E-1	0	**04-05 E-1 rate =**	**595,652**
Mode E-1	0		

The numbers of observations were used with the annual E-1 rates in a Chi-Square analysis to determine statistical correlation. The Chi-Square was determined to be 81.366 by the calculations shown in Table 3. Table 1 and Table 2 provided the annual E-1 rates and the number of observations performed.

TABLE 3
Chi-Square Calculations

yr.	Observations	E-1 Rate
04-05	0.0000	53090.9167
05-06	913.0000	595652.0000

Sum A+B	53090.92
Sum B+C	596565
Sum A+C	648742.9
Sum B+D	913
N=A+B+C+D =	649655.9167

$$\chi^2 = \frac{N\,(AD-BC)^2}{(A+B)\,(C+D)\,(A+C)\,(B+D)}$$

$$\chi^2 = \frac{1.52639E+21}{1.87595E+19}$$

$$\chi^2 = 81.3662$$

Further statistical analysis used the t-test to determine the statistical difference between the mean number of E-1s from the two sample years. The calculations yielded a t-test of 17.573. The calculations for the t-test analysis were placed in Table 4.

TABLE 4
t-test Calculations

Mean 04-05 E-1s	1.0000

	d	d2
1	0.0000	0.0000
0	-1.0000	1.0000
0	-1.0000	1.0000
0	-1.0000	1.0000
1	0.0000	0.0000
3	2.0000	4.0000
0	-1.0000	1.0000
2	1.0000	1.0000
2	1.0000	1.0000
0	-1.0000	1.0000
2	1.0000	1.0000
1	0.0000	0.0000
		12.0000

Mean 05-06 E-1s	0.0833

	d	d2
0	0.0833	0.0069
0	0.0833	0.0069
0	0.0833	0.0069
0	0.0833	0.0069
0	0.0833	0.0069
0	0.0833	0.0069
0	0.0833	0.0069
1	0.9167	0.8403
0	1.0000	1.0000
0	0.0833	0.0069
0	0.0833	0.0069
0	0.0833	0.0069
		1.9097

$$t = \frac{M1-M2}{\sqrt{\left(\frac{\sum d_1^2 + \sum d_1^2}{N_1N_2-2}\right)\left(\frac{N_1+N_2}{N_1N_2}\right)}}$$

$$\frac{0.9167}{\sqrt{0.05216}}$$

N1=12
N2=12

df=N1+N2-2

df=22

t= 17.573

SUMMARY

Chapter IV presented the statistical analysis of this study. Chi-Square was calculated to determine the correlation of the number of observations performed and the number of safety incidents. A t-test calculation was performed to provide further statistical analysis and to determine if there was a significant difference between the two sample means of the E-1 data over the two year period. Chapter V will provide a summary of the problem and the data collected, conclusions of the study, and future recommendations for the study.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Chapter V presents the results of the study. The chapter is divided into three sections, summary, conclusion, and recommendations. The summary section summarizes the work that was proposed. The conclusion section provides the conclusion drawn from the data collected. The recommendations section provides recommendations for further study.

SUMMARY

The problem for this study was to determine if the implementation of the behavior-based safety program at the ROME contract NASA Langley Research Center lowered the amount of safety incidents. The hypothesis of the study was a predictive hypothesis and was stated as follows: H_1: There was an direct correlation between the number of behavior based safety observations performed and safety incident rate of the employees under the ROME contract. The research was determined to be an experimental study using behavior-based safety observations as the independent variable and the E-1 rate as the dependant variable.

Work place related injuries have cost U.S. employers billions of dollars in direct cost each year. By implementing a program that can recognize employee's behaviors that put them at risk of having an injury or accident and helping them to change those identified behaviors, the employees will have a lower chance of being involved in an accident or being injured in the work place. This study was focused on a new safety program that claims to offer such results to employers. If the program is successful the

results can be presented as an example of how the program can help the employees avoid injuries and lower the number of workplace injuries for employers.

The study was guided by the following limitations:

1. The results of the study were limited to the ROME employees at NASA Langley Research Center.
2. The study relied on the number of behavior-based safety observations performed by ROME employees.
3. Participation in the behavior-based safety observation process was on a voluntary basis for all ROME employees.
4. Safety incidents and safety observations were tracked over a one year time period starting with the first behavior-based safety observations.
5. The safety incident rate from the year prior to the start of the study will be used as a baseline.

The population of the study consisted of approximately 400 employees that were currently working under the ROME contract at the NASA Langley Research Center. The instrument used for this study was the behavior-based safety observations using the behavior-based safety observation check list.

The data were collected by two different sources. The behavior-based safety committee provided the number of observations performed by month over the first year of the program, November, 2005, through October, 2006. The contract safety department manger provided the number of hours worked and the number of E-1s experienced by month for the two year period starting November, 2004, through October, 2006.

The data collected was used in a bivariate tabular analysis using Chi-square, and was used to determine the statistical correlation between the dependant (behavior-based safety observations) and independent (E-1 rate) variables. Further statistical analysis was performed using t-test analysis to determine the relationship between the two sample means (the base line against the control group) using the number of E-1s that occurred in the two year period. The baseline was determined by using the number of E-1s experienced during the year preceding the implementation of the behavior-based safety program. The control group was determined to be the number of E-1s experienced during the first year of the behavior-based safety program. Both forms of statistical analysis used the raw data collected to determine correlation of the data and the level of significance.

CONCLUSIONS

The hypothesis for this study was:

H_1: There was a direct correlation between the number of behavior-based safety observations performed and safety incident rates of the employees under the ROME contract.

The bivariate tabular analysis using Chi-square and the raw data collected yielded a value of 81.3662. The Chi-square (χ^2) value was 81.3662. From the table of significance the researcher found the value exceeds 5.410 at the 0.01 level of significance; therefore, we can accept the hypothesis. Based on these findings, the researcher concludes there is a direct correlation between the number of behavior-based safety observations performed and safety incident rates of the employees under the ROME contract.

Further statistical analysis was performed using a t-test to compare the two statistical means of the E-1s. This analysis yielded a value of 17.573. The t-test value of 17.573 exceeds the 2.508 at the 0.01 level of significance; therefore we can accept the hypothesis. From these findings, the research concludes there was a significant difference between the two sample means. Therefore, the introduction of the behavior-based safety program did have a strong correlation in lowering the number of safety incidents.

RECOMMENDATIONS

The findings of this study suggest the implementation of the behavior-based safety program lowered the number of safety incidents. Based on the conclusions of this study, the researcher recommends the following:

1. Further research should be done on behavior-based safety programs that are in a mature level to determine their long term benefits.
2. The results of this study should be used when initiating a behavior-based safety program at different company sites. To help gain support and acceptance of the program, this study could be used as an example of how implementing a behavior-based safety program can improve safety performance.
3. Further research should be done on facilities adopting the company's safety program without the behavior-based safety program to provide a comparison to this study. This comparison can help show if the results of the study were from the behavior-based safety or the company's overall aggressive approach to safety.

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Appendix A

ROME Group Behavior-based Safety Observation Checklist

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Rome Safety Awareness Report Checklist

Observer's Name: Organization: CP☐ EN☐ FO☐ IS☐ MA☐ SH☐

Task: Date:

When observing, ask: Is this person in a position where he/she could get hurt by one of the following?

	Safe	At Risk	N/A		Safe	At Risk	N/A
PPE				**Tools**			
Hard hat	☐	☐	☐	Correct tool used and has current inspection	☐	☐	☐
Safety glasses w/side shields	☐	☐	☐	Tool used correctly and with 2 hands if req'd.	☐	☐	☐
Appropriate footwear	☐	☐	☐	Equipment/tool guards in place & functional	☐	☐	☐
Hearing Protection	☐	☐	☐	Sufficient lighting for task being performed	☐	☐	☐
Hand Protection	☐	☐	☐	Material secure while working on it	☐	☐	☐
Full Face Shields/Goggles	☐	☐	☐	Aware of surroundings (people, equipment)	☐	☐	☐
Chemical Aprons	☐	☐	☐	Protective/Containment screens used	☐	☐	☐
Procedures				**Are Employees In The Line Of Fire?**			
Is SPA adequate & being followed?	☐	☐	☐	Protected from overhead hazards?	☐	☐	☐
Does SPA identify PPE to mitigate hazard?	☐	☐	☐	Have pinch points been mitigated?	☐	☐	☐
Was SPA reviewed and updated?	☐	☐	☐	Are others protected from work being done?	☐	☐	☐
Work Permits used/followed?	☐	☐	☐	Is task in the "Line of Sight?"	☐	☐	☐
Is equipment used properly?	☐	☐	☐	Are sharp edges protected?	☐	☐	☐
Is other procedure adequate?	☐	☐	☐				
Is SPA on job site and signed by all on site, including observer?	☐	☐	☐				
Scaffolding & Barricade Use				**Housekeeping**			
Barricades used when required?	☐	☐	☐	Is general housekeeping adequate?	☐	☐	☐
Barricade adequate/correct type?	☐	☐	☐	Trip hazards protected or removed?	☐	☐	☐
Barricade tags followed?	☐	☐	☐	Flammable material stored correctly?	☐	☐	☐
Scaffolding correct/used properly?	☐	☐	☐	Cord/hose management?	☐	☐	☐
Was staging inspected for use?	☐	☐	☐				
Manual Lifting and Body Position				**Fall Protection and Ladders Use**			
Knees bent/back straight?	☐	☐	☐	Holes properly covered?	☐	☐	☐
Body position correct/not twisted?	☐	☐	☐	Employee setup/tied off as required?	☐	☐	☐
Help for bulky or heavy items?	☐	☐	☐	Using ladder correctly?	☐	☐	☐
				Using stairs correctly?	☐	☐	☐
Office Environment				**Vehicle Operations**			
Appropriate footwear?	☐	☐	☐	Following ROME vehicle operating policy?	☐	☐	☐
Proper ergonomics?	☐	☐	☐	Following ROME backing policy?	☐	☐	☐
Proper use of office equipment?	☐	☐	☐	Properly secured loads?	☐	☐	☐
Proper use of facility infrastructure?	☐	☐	☐	Seat belts worn?	☐	☐	☐
(i.e. handrails,doors,steps,etc)	☐	☐	☐				

Observer's Summary Comments

Safe Acts:

At-Risk Acts:

Feedback from Person(s) Observed:

Notes for Behavioral Safety Observation

Procedure

- Use defined checklist
- Conduct situational observation of work area
- Ask person you if you can observe them
- Observe employee(s) working
- Complete Behavioral Safety Observation Report
- Note safe behaviors
- Write actual behavior for each at-risk behavior
- Tell person(s) when observation is completed
- Explain positive findings to person(s) observed
- Provide guidance feedback to person(s) observed for at-risk behavior
- Note corrective actions taken
- Note recommendations (yours and person(s) observed) for equipment or procedure changes where appropriate
- Submit checklist for summarization

Tips

- Be careful not to startle the employee you are planning to observe when you ask them if you can observe them.
- Be polite. Remember the golden rule and treat everyone like you would like to be treated.
- If you do not know whether or not a situation is safe, consult with the employee(s) being observed. If you are still unsure you can discuss it with the supervisor or HSE department or submit question on your observation form.
- Never argue with the person being observed; simply agree to disagree and turn the issue over to the Safety Leadership Team by putting the issue on your form under the section for "Feedback From The Person(s) Being Observed."
- If you observe an unsafe or good safe behavior that is not on the form, please note it on the form and discuss it with the employee. We want to learn about other behaviors that may help us or that may prevent future accidents.

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