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Using Behavioral Based Safety to Enhance Safety Performance

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Abstract: Safety in the construction industry has progressed exponentially in the last century. The development of the Occupational Safety and Health Administration (OSHA) may be seen as a major milestone for work place safety. However, the first stages of OSHA were reactive. In the early 2000's, companies placed aggressive focus on the application of proactive measures in preventing incidents rather than simply reacting. Risk Assessments, Constructability Reviews, and Hazard Identifications were few of the best practices implemented in this time period. Experts now believe the implementation of a Behavioral Based Safety Program (BBS) is the next revolutionary technique to help decrease injury rates further. Several studies were conducted which exhibit a correlation between effective BBS implementation and OSHA classified recordable injury rates. However, there are no previous studies identifying correlation between BBS implementation versus Near Misses, and BBS implementation versus OSHA classified First Aid Cases. This paper helps identify whether BBS implementation on a typical Petrochemical/refinery construction project impacts the number of Near Misses and First Aid Cases. BBS was implemented on 14 different construction projects within Technip, collecting all BBS and incident data, and applying different analysis techniques to identify existing trends between BBS observations/First Aids Cases/Near Misses. It helps identify whether BBS improves the safety performance on a job site by identifying its impact on injuries, in addition to Near Miss reporting. The paper will assist similar companies with evaluating whether the implementation of a BBS program yields favorable results to the safe performance of their projects.
Keywords: Safety; near miss; first aid; injury rate; OSHA; behavioral based study program (BBS).

1. Introduction

The introduction of the Behavioral Based Safety (BBS) program has the potential to increase safety performance and decrease injuries on a construction project. Geller [1] reported that behavioral-based safety (BBS) provides tools and procedures that workers can use to take personal control of occupational risks. BBS utilizes the process of intervention to correct or encourage observed behavior on the job site. This approach helps empower the individual towards performing a specific activity safely and stop an unsafe act before it turns into an injury.

BBS has also received some criticism in recent years as being ineffective. Skeptics state BBS tends to place the responsibility of safety on the workers rather than on the organization- which is a potential OSHA violation. BBS, as the name implies, focuses entirely on the behavior or acts of the workforce, which may be a shortfall of the overall process. Jackie Nowell, director of occupational safety and health for the United Food and Commercial Workers International Union in Washington, stated the following: "In our industries, there are abundant hazards. We believe that needs to be the focus of any safety program- that you go looking for the hazard, not the careless act. Once you've cleaned up all the hazards, fine- go find the careless acts" [2].

Several studies revealed that roughly 90% of all injuries are caused by unsafe acts or behaviors [3]. A recent study conducted by Conoco Phillips in 2003 suggested that for every fatality there are at least 300,000 at-risk behaviors. Theoretically, eliminating the unsafe acts on the bottom of the safety triangle should result in overall injury reduction.

Figure 1 also suggests a reduction in unsafe acts through increased number of BBS observations would result in fewer Near Misses. A Near Miss is defined as an unplanned event that did not result in injury, illness, or damage, but had the potential to do so. One of the most common problems faced on construction projects is

insufficient Near Miss reporting. This causes missed opportunities in identifying root causes and implementing appropriate corrective actions to prevent similar types of incidents. Few hypothesize that increased BBS observations will cause the workforce to increase their level of safety awareness and therefore report more Near Misses as they occur.

Many opposing views on the effectiveness of a BBS program raise an interesting issue. Does the benefit of BBS on a job site outweigh the costs and efforts associated with its implementation? In other words, does a BBS program strongly correlate with the reduction of injuries (specifically First Aid cases)? Will the increase in BBS observations cause an increase in Near Miss reporting or will it reduce the number of Near Misses even further?

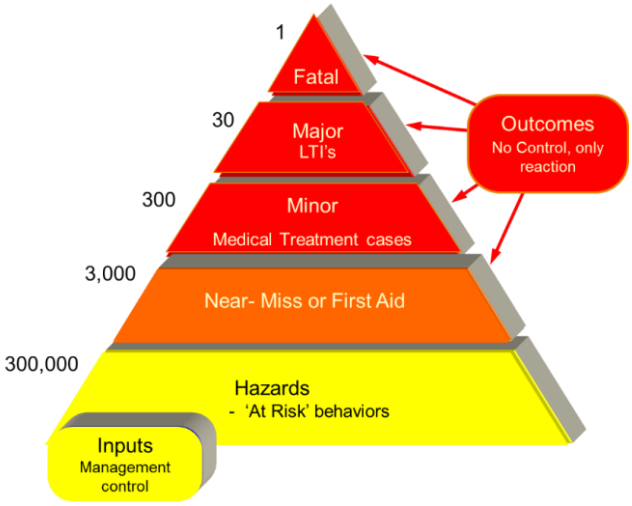

Figure 1. Safety triangle

2. Objectives

The main objective of this project is to further expand on previous research regarding implementation of BBS and obtain a better understanding of its impact on the safety in a particular project. This research will provide further knowledge and insight towards the effect of a BBS program on the number of incidents on a job site. Incidents will include First Aid Treatment Cases (as defined by OSHA) and Near Misses. Sub-objectives will include:

1) Implement a BBS program on 14 different EPCM petro chemical plants and refineries projects.

2) Track the number of BBS observations conducted and the number of incidents on a monthly basis for 12 months beginning on March 1, 2015 for each project. Both the incidents and the BBS observations will be tracked in parallel at the same time.

3) Extract data and identify the correlation between the number of Observations made and the different types of incidents. Specific incidents to be tracked will include Near Misses and First Aids only.

3. Literature review

Krause et al. [4] reported that BBS is an effective tool in increasing safe behaviors and decreasing injury rates. In their study, up to 5 years of injury data from 73 companies, drawn from a target population of 229 companies which implemented behavior-based safety, were examined. They showed comparisons of pre- to- post initiative incident levels across groups revealed a significant decrease in incidents following the behavior-based safety implementation. Companies decreased their Recordable Incident Rate, on average, by 26% by the first year and 69% by the fifth year. This study limited its evaluation to only identifying the impact on OSHA classified Recordable Injuries and excluded First Aids and Near Misses.

Choudhry [5] examined the impact of BBS on 5 major risk categories, namely, PPE, Housekeeping, Access to Heights, plant and equipment, and scaffolding (Figure 3). These categories were evaluated prior to implementing BBS and given a specific Safety Score based on multiple factors for each category. These initial scores served as the baseline for the study. BBS was then implemented on the project and all progress was tracked on a weekly basis. After 9 weeks of tracking, findings have shown an increase of the Safety Score in all 5 risk categories. There was an average 6% increase in the cumulative score for all 5 risk categories. Figures 2 and 3 shows the progress for the PPE and Scaffolding categories, respectively.

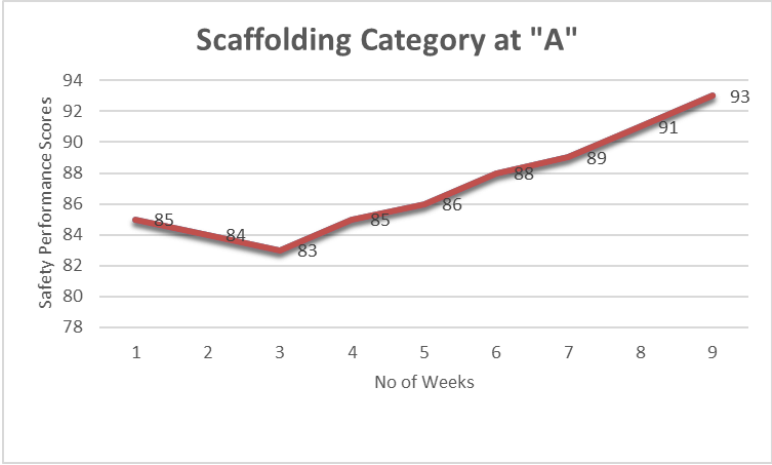

Figure 2. Safety performance scores for scaffolding category at project "A"

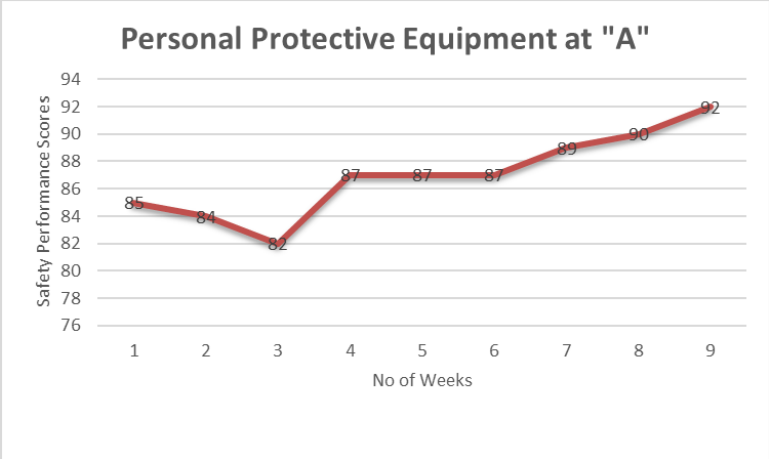

Figure 3. Safety performance scores for personal protective equipment at project "A"

Based on the evaluation of previous studies on BBS implementation, the impact of BBS implementation on First Aids and Near Misses was not identified. Does the implementation of BBS increase Near Miss reporting by increasing the safety awareness of the workforce? Does it decrease the amount of First Aids by creating a safer environment? Or is there no actual correlation between the two variables? The focus of this research is to help answer some of these questions.

4. Research Methodology

Behavioral Based Safety (BBS) process serves one main purpose, which is to observe and correct at-risk or unsafe behavior. BBS process is often described as a bottom-up approach by providing frontline supervision and/or craft with a specific process to observe their fellow peers and provide immediate feedback/coaching on the safe execution of the task observed.

The very first step is to implement the BBS program on the project is to ensure all observers are trained in the company BBS process. Training will be provided to all workers and supervision as they mobilize on the project as part of their orientation and on-boarding process. BBS training module will last approximately 1.5 hours and will cover the topics specified below:

1) HSSE Culture Attributes- Specifically discusses the different HSE culture types (Reactive, Compliance, Independent and Dependent) how they correlate with the number of injuries a company experiences. The objective of this part of the training is to communicate the value a strong HSE culture would bring to the project and organization.

2) Over 90% of incidents are caused by unsafe acts- Discuss the DuPont study which concludes approximately 96% of injuries are caused by an unsafe act rather than an unsafe condition. The purpose of this topic is to ensure we are focusing on the behavioral aspect of observations.

3) BBS 5-Step Cycle- this cycle will include:

a) Personally decide to be passionately engaged in the BBS process.

b) Stop near people to see what they are doing. Glancing as you go by is not effective

c) Observe people in a careful, systematic way, looking at everything they are doing and focusing on unsafe acts.

d) If you see unsafe acts, you act to correct the situation and prevent recurrence. This includes talking and sharing your safety standards so they understand why their act is hazardous.

4) Discussion of the project BBS card and the different sections that the observers will need to fill out and be familiar with.

5) Card submission process

Personnel to be trained will include all craft labor, foremen, superintendents, project management, and site visitors. Once all of the observers are trained, the project will be utilizing the BBS cards provided below to document all observations. The administrator on the project will collect all cards submitted for the month and enter the total number of observations into the company HSE Database by the first week of each month along with the number of injuries and Near Misses. The card to be used contains 13 different categories as shown in Figure 4. Categories identified on this card were based on the company most hazardous operations as it relates to construction.

All trained observers will receive the cards provided above to facilitate their behavioral observations. This card will be used as a tool to assist in guiding the observer in their specific behavioral observations. The 13 categories identified on this card include:

a) Housekeeping/Sanitation
b) Fall Protection and Prevention
c) Scaffolds, Ladders, Stairways
d) Personal Protective Equipment
e) Control Procedures and Permits
f) Excavation and Trenching
g) Hoisting/Rigging
h) Motor Vehicles/ Mobile Equipment
i) Tools and Equipment
j) Fire Prevention
k) Manual Material Handling
l) Electrical

As seen on the card provided in Figure 4, each of the different categories contains essential criteria to evaluate the behavior observed. Additionally, the observer has the flexibility to document both a safe and unsafe observation. Observers are trained to recognize safe behavior and individually recognize the individual they observed for positive reinforcement. In order for an observation to remain valid, five steps must be satisfied:

1) Care- the individual making the observation must make the initial commitment to care and want to make a difference in the safety of the organization. Without caring, the BBS process will not serve its purpose and will result in personnel submitting inaccurate results.

2) Observation- an individual who is trained on the company BBS process must stand and observe a selected individual or activity, carefully focusing on the task being performed and if the task is being executed safely.

3) Intervention- Once the observation is complete; the observer must approach the individual and provide immediate feedback on the safety of the task being executed. The observation may be include correcting the unsafe behavior observed or applauding the individual for executing the observed task safely. In either case, the observer must approach the individual and make the personal engagement.

4) Elimination- If the task was observed to be executed unsafely, both the observer and individual observed must have a group discussion on what needs to be done differently to ensure the same task is executed safely in the future. If the task being observed was executed safely, the observer must reinforce the safe behavior.

5) Documentation- The act and/or task observed along with the conversation is then documented on a company-specific BBS (provided above) card and filed with the project administrator for tracking and trending. The admin then collects all cards for any given month and enters the total number of observations into the company HSE database along with the First Aids and Near Misses.

All submitted observations will be tracked on a monthly basis in parallel with the different types of incidents. The data collection phase of this research will begin March 1, 2015 until February 29, 2016. The purpose of this research is to identify the correlation between the number of observations and number of the incident types previously specified (Near Misses and First Aids).

COURAGE TO CARE CONVERSATION CARD

Date: Work Area:

Observer Name:

1.0	Housekeeping & Sanitation	Safe	Unsafe
1	Aisles/Walkways		
2	Cords/Hoses		
3	Drinking Water		
4	Sanitary Facilities		
5	Trash Receptacles- overflow		
6	Waste Management		
2.0	**Fall Protection & Prevention**	**Safe**	**Unsafe**
1	Anchor Point		
2	Lifelines/Handrails		
3	Floor openings/ covers/ barricades		
4	Use of Personal Fall Protection		
3.0	**Scaffolds, Ladders & Stairways**	**Safe**	**Unsafe**
1	Tag(s) for scaffold in use		
2	Scaffold built appropriately		
3	Ladder tied off/inspected		
4	Ladder extends 3 rungs		
5	Stairs guarded- handrail/ midrail		
6	3 point contact		
4.0	**Personal Protective Equipment**	**Safe**	**Unsafe**
1	Eye/Face/Head		
2	Hand		
3	Hearing		
4	Foot		
5	Body		
6	Respiratory		
5.0	**Control Procedures and Permits**	**Safe**	**Unsafe**
1	Confined Space Entry		
2	Lockout/ Tagout		
3	First Line Break		
4	Energy Isolation		
5	Critical Lift		
5	Hot Work		
6	Rescue Plan/ Rescue Team		

6.0	Excavations and Trenching	Safe	Unsafe
1	Shoring/ Sloping		
2	Access/ Egress/barricades		
3	Spoil Location		
4	Equipment location sability		
7.0	**Hoisting / Rigging Equipment**	**Safe**	**Unsafe**
1	Load Rigged Correctly		
2	Equipment condition/ inspection		
3	Lift area clear/ barricades		
4	Equipment not overloaded		
5	Crane outrigger pads		
6	Overhead powerline proximity		
7	Hand signals/ communication		
8	Signal person		
8.0	**Motor Vehicle and Mobile Equipment**	**Safe**	**Unsafe**
1	Inspection/ condition		
2	Horns/ alarms		
3	Qualification/ certification		
4	Pinch points/ line of fire		
9.0	**Tools and Equipment**	**Safe**	**Unsafe**
1	Inspection/ Condition		
2	Appropriate for Task		
3	Guards		
4	Pinch Points/ Line of Fire		
10.0	**Fire Prevention**	**Safe**	**Unsafe**
1	Flammable Storage		
2	Fire Extinguishers		
3	Area clear for hot work		
11.0	**Manual Material Handling & Ergo**	**Safe**	**Unsafe**
1	Vibration		
2	Body Position		
3	Lift/ Lower/ Push/ Pull		
4	Work/ Rest		
12.0	**Electrical**	**Safe**	**Unsafe**
1	Inspection/ condition		
2	GFCI		
3	High Voltage Proximity/ Barriers		
13.0	**Other**	**Safe**	**Unsafe**
14.0	**Was the conversation well received?**	**Yes**	**No**

Unsafe Act Observed	
Immediate Corrective Action/Action to Prevent Recurrence	

Figure 4. Behavioral Based Safety (BBS) Card

A total of 14 different projects will be evaluated for this study. Due to the lack of historical data, there will be no baseline and all trends will be evaluated from zero. In other words, statistical analysis will be conducted with the number of observations serving as the independent variable and number of Near Misses and First Aids being the dependent variables.

The total current value of each project to be evaluated varies from $30 M to $8.9 B. Two different software will be used to track all of the observations and incidents on the project. Both of the software will be managed by a designated administrator to ensure timely reporting and overall quality of the data entered.

5. Analysis

Specific statistical analysis performed, once all of the data was collected, included simple correlation analysis, regression analysis, range transformation, value transformation and Historical trending. Summary of the findings for each analysis performed is as follows:

5.1. Correlation Analysis

A simple correlation analysis was the first step conducted with the 12 months' worth of data. A sum of observations and incidents (First Aids and Near Misses) were completed for all 14 projects. The cumulative numbers were then segregated by month to provide a general overview of any existing trends/correlation between the data sets. Table 1 summarizes the cumulative overview for all projects by month. Figures 5 and 6 show the correlation analysis of near miss and first aid and results, respectively.

The initial analysis results show a strong increasing correlation with increasing Near Misses and a strong decreasing correlation with First Aid injuries. This supports the assumption that the increase in observations reporting raises the safety culture and therefore increases Near Miss reporting within the organization. This also leads to a decrease in the number of first aid injuries.

5.2. Regression Analysis

Once the general correlation results were documented, a supplemental regression analysis was completed on the 12 cumulative data points for the purposes of verifying evidence of a linear relationship. Figures 7 and 8 show the regression analysis of first aid and near miss results, respectively.

1) Coefficient of determination for Observations vs Near Misses is. 6323. (63.23% of the variation in Observations is explained by the variability in the Near Misses.)

2) P Value for Observations vs Near Misses is .00199 which means there is significant evidence of a linear relationship because p values are less than the significance level of .05.

3) Coefficient of determination for Observations vs. First Aids is .6726. (67.26% of the variation in Observations is explained by the variability in the First Aids.)

4) P Value for Observations vs. First Aids is .001085 which means there is significant evidence of a linear relationship because p values are less than the significance level of .05.

Table1. Cumulative number of observations and incidents for all projects by month

Time Period (Months)	Observations	Near Misses	First Aids
January	151433	77	92
February	144122	68	92
March	177766	84	75
April	198392	88	69
May	197832	80	74
June	203782	91	68
July	200072	88	78
August	158151	80	88
September	172910	80	70
October	173141	74	81
November	183517	84	71
December	189833	77	72

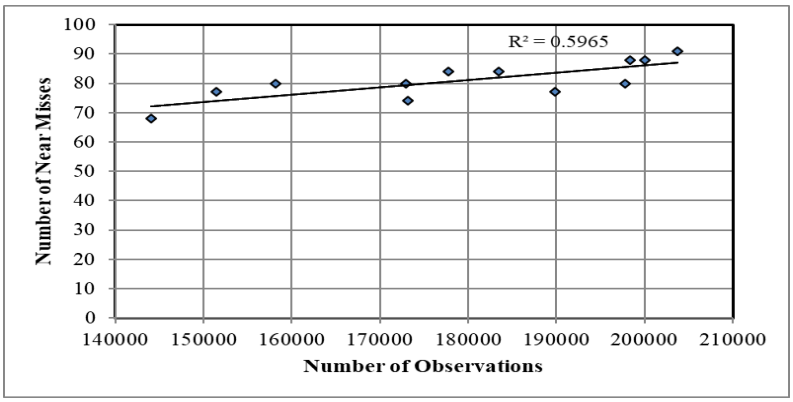

Figure 5. Observations versus Near Misses Results

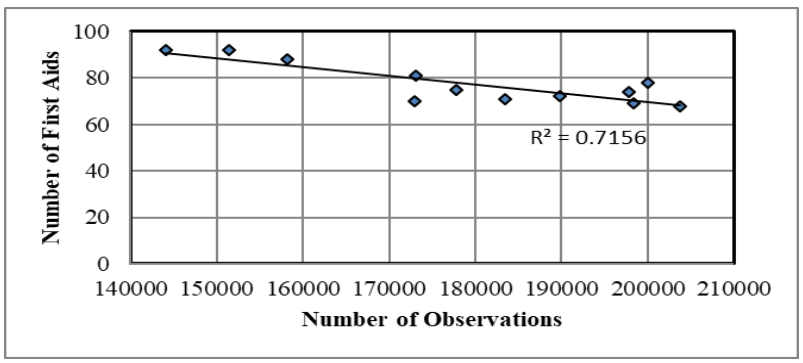

Figure 6. Observations versus first aid results

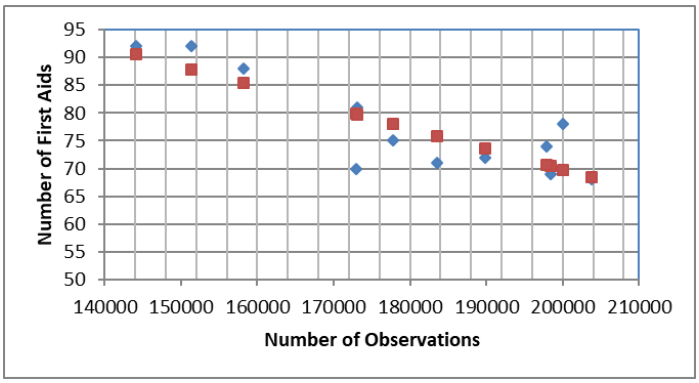

Figure 7. First aid first regression results

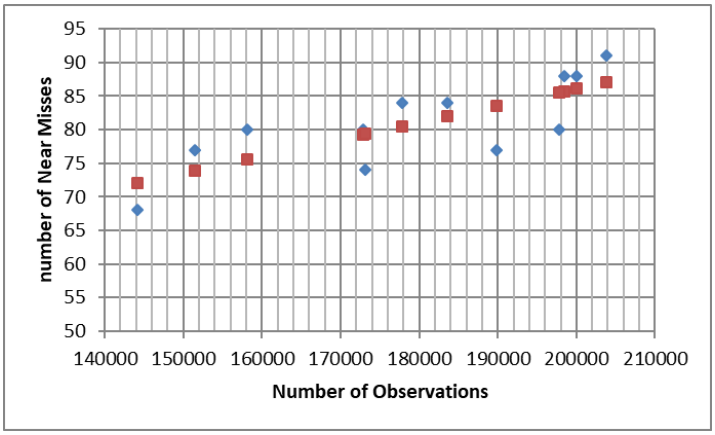

Figure 8. Near miss first regression results

The analysis results show a strong increasing correlation with increasing Near Misses and a strong decreasing correlation with First Aid injuries. However, the data evaluated was a summation of all 14 projects, therefore providing an analysis of only 12 different observations. The sample pool and number of observations had to be expanded to ensure reliable findings. An additional regression analysis was completed for each individual data point instead using the sum. This exercise increased the observation pool from 12 to 168 and significantly changed the findings of the data (Refer to Figures 9 and 10):

1) Coefficient of determination for Observations vs Near Misses is .3884. (38.84% of the variation in Observations is explained by the variability in the Near Misses.)

2) P Value for Observations vs Near Misses is $1.86x10^{-19}$ which means there is significant evidence of a linear relationship because p values are less than the significance level of .05.

3) Coefficient of determination for Observations vs. First Aids is .3584. (35.84% of the variation in Observations is explained by the variability in the First Aids.)

4) P Value for Observations vs. First Aids is $1.02x10^{-17}$ which means there is significant evidence of a linear relationship because p values are less than the significance level of .05.

5.3. Value Transformation

In an attempt to further eliminate high degrees of variations and outliers, all data points were transformed with a standard log function. Each listed observation, First Aid, and Near Miss count was transformed by computing its log. Once all values were transformed, the regression analysis was recalculated to note any changes in the findings (Figures 11 and 12):

1) Coefficient of determination for Observations vs Near Misses is .3851. (38.51% of the variation in Observations is explained by the variability in the Near Misses.)

2) P Value for Observations vs Near Misses is $3.1521x10^{-14}$ which means there is significant evidence of a linear relationship because p values are less than the significance level of .05.

3) Coefficient of determination for Observations vs. First Aids is .3586. This means 35.86% of the variation in is Observations explained by the variability in the First Aids.

4) P Value for Observations vs. First Aids is $2.41x10^{-13}$ which means there is significant evidence of a linear relationship because p values are less than the significance level of .05.

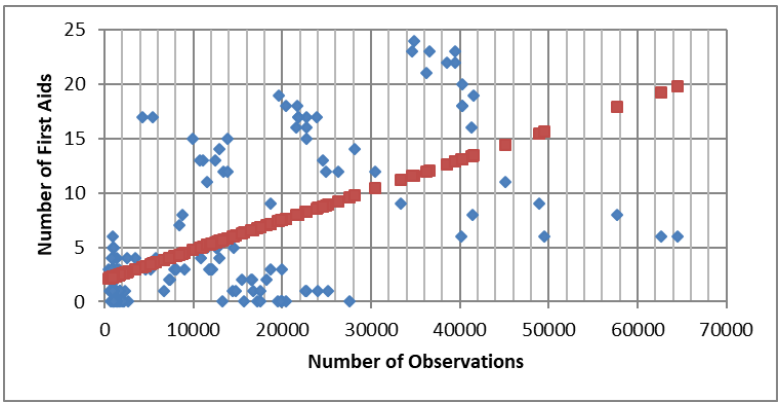

Figure 9. First aid second regression results

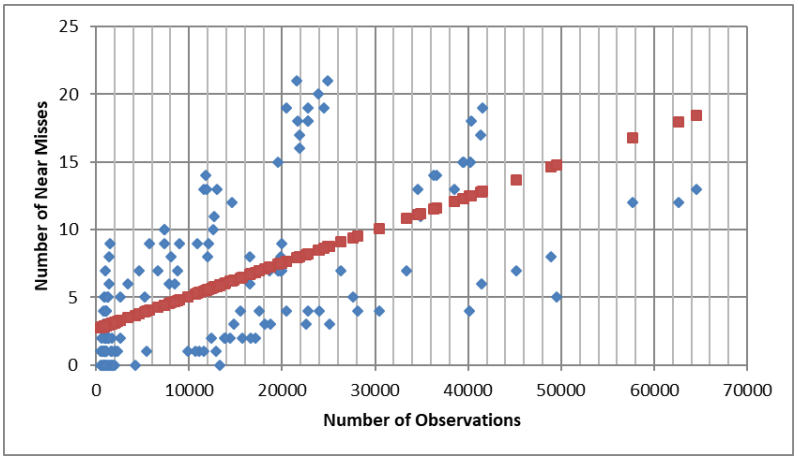

Figure 10. Near miss second regression results

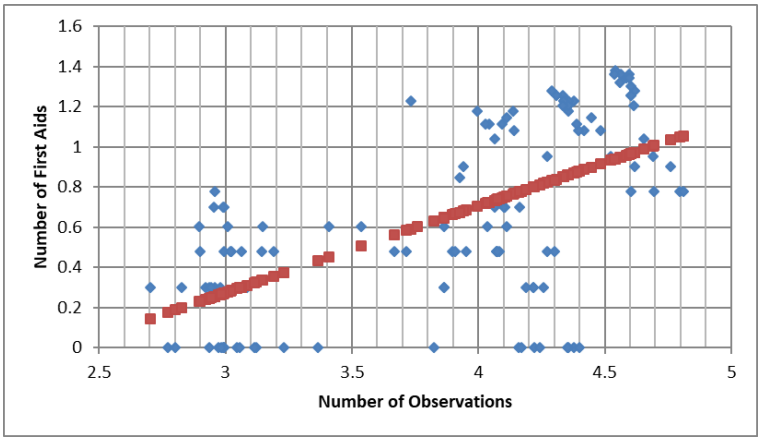

Figure 11. First aid third regression results

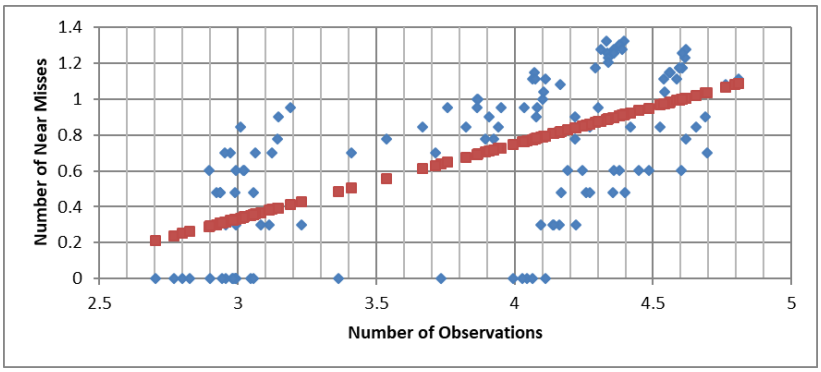

Figure 12. Near miss third regression results

6. Discussion

6.1. Correlation Analysis

The initial results showed a strong positive correlation between the number of observations vs. Near Misses with an R^2 of .5965, and a strong negative correlation between the number of observations and First Aids with an R^2 of .7156. This suggested a probable increase in Near Miss reporting due to a raised safety awareness driven by the increased number of Behavioral Based Observations.

6.2. Regression Analysis

The data set exhibited to remain reliable with P-values lower than the significance level of .05. As a result of the sample pool expansion, the correlation changed from strong positive to moderate positive between Near Misses reporting vs BBS Observations, and from strong negative to a weak positive correlation between number of First Aids and BBS observations

6.3. Value Transformation

Conducting Value transformation did not provide sufficient evidence to support a correlation between observations, near misses and first aids. Correlation between observations and near misses was identified to remain weak in addition to the correlation between observations and first aids.

7. Conclusion

The data evaluated in this report only included Technip owned projects and was limited to construction of petrochemical plants and refineries. The 14 total projects evaluated was a mixture of six Greenfield and eight Brownfield projects. Although the data evaluated was only from Technip owned projects, the findings of this report may be valid for other companies as guidance in considering the implementation of a Behavioral Based Safety program on particular project or site location. The findings of this report may not apply to projects within the Offshore or Subsea construction sectors.

The cards captured both positive and negative observations, however the data evaluated in this report includes the sum of all safe and unsafe observations for each month. This may be a limitation when evaluating the correlation between observations and First Aids since it will not capture the impact of safe vs unsafe observations.

Since the basis of BBS is engaging all levels of the work force, the overall goal is to improve safety culture. By improving safety culture, we typically expect to observe increased Near Miss reporting and decreased number of injuries, or in this case First Aids. Based on the different statistical analysis performed, it is evident that the 14 different projects analyzed in this study did not strongly support this claim. Correlation analysis proved to support the original hypothesis the most, however, the sample pool in this analysis was too small to make an informed conclusion.

To better optimize this study in the future, gauging the quality of each BBS observation submitted is critical to ensuring reliable data. This study was solely analyzing the observation numbers based on the total number of participants rather than evaluating each of the observations for quality. In this case, a good quality observation is one that involves a conversation by the observer to either correct an unsafe behavior or reinforce a safe behavior. The conversation has to also be well-received by the individual being observed to ensure the desired action is sustainable. As a further expansion of this study, it is recommended to design a mechanism to gauge the quality of the observations and conduct a separate analysis utilizing only the high quality observations.

8. References

[1] Geller, S. Behavior Modification. Behavior-Based Safety and Occupational Risk Management. 2014:29(3), 539-561.

[2] Greene, M. Behavior-based safety: A study of pros and cons. http://www.safetyandhealthmagazine.com/articles/behavior-based-safety-a-study-of-pros-and-cons-2. 2009.

[3] E.L DuPont de Nemours and Company. Dispersed Work Sites are not a Barrier to Communication. http://www.dupont.com/content/dam/dupont/products-and-services/consulting-services-and-process-technologies/consulting-services-and-process-technologies-landing/documents/Conoco_Communication_CaseStudy.pdf. 2007

[4] Krause, T., Seymour, K., & Sloat, K. Long-Term evaluation of a behavior-based method for improving safety performance: A meta-analysis of 73 interrupted time. 1998

[5] Choudhry, M. Rafiq. Behavior-based safety on construction sites: A case study. Accident Analysis and Prevention, 2014:70, 14-23.