Journal of Mechanical, Elecrical & Industrial Technology **Vol. 1, No. 2**
e-ISSN 3047-7778 **September 2024**

Enhancing Worker Safety Behaviors Through Proactive Interventions in the Lifting and Transport Equipment Industry

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Abstract

Unsafe worker behavior remains a prevalent issue leading to workplace accidents, particularly within companies specializing in services for head truck operations, maintenance, and lifting equipment. This study aims to enhance worker safety behaviors through proactive interventions utilizing behavioral observation and intervention (BO&I). Additionally, trend analysis is employed to predict the impact of interventions on worker safety behaviors. Mechanical workers involved in lifting and transport equipment operations are surveyed as respondents. The findings reveal a notable increase in the percentage of safe behaviors post-intervention compared to pre-intervention levels. Moreover, disparities in worker safety behaviors between pre-and post-intervention stages are identified, particularly in work stages associated with a high frequency of accidents. Trend analysis forecasts that the maximum percentage of safe worker behavior will be observed at the 91st intervention. Furthermore, binary logistic regression analysis indicates that variables such as age, length of work, utilization of personal protective equipment (PPE), and education do not affect worker behaviors.

Keywords: behavioral observation and intervention; worker behavior; trend analysis test; binary logistic regression.

1. Introduction

In the industrial setting, accidents are a major concern due to their potential to cause injuries, fatalities, and property damage. Accidents in the workplace can have severe consequences in terms of human suffering (Dodoo and Al-Samarraie, 2023) and economic costs (Mazzolini, 2020). A fatality or injury can cause physical and emotional trauma as well as financial hardship. It is also possible for accidents to result in downtime, lost productivity, equipment and facility damage, and legal liability, all of which can have long-term effects on an organization.

A work accident is the end of a cause-and-effect sequence that is usually triggered by unsafe behavior. There are five factors that are interconnected in explaining the occurrence of work accidents based on Heinrich Theory (Domino Theory), i.e.: Ancestry and social environment, Worker fault, Unsafe act together with mechanical and physical hazard, Accident, Damage or injury (ILO, 2018).

A Heinrich study, well-known as Heinrich Law of Safety, estimated that unsafe acts caused eighty-eight percent of all near-misses and workplace injuries (Geller, 2001). Furthermore, behavior-based research studies have evaluated the impact of safety interventions to increase workers' safe behaviors. The feedback from behavioral observations would be an indication of successful interventions. A review by Dyreborg et al., (2022) concluded that some types of safety intervention, such as safety campaigns and training; and behavioral-based safety interventions have insufficient or limited evidence.

Since unsafe behavior is the main contributor to work accidents, reducing work accidents can be achieved by focusing efforts on reducing unsafe behavior and implementing behavior-based safety in the workplace. To be able to achieve safe behavior, it is necessary to identify target behavior that can be observed to be changed and environmental conditions that can be manipulated to influence the target behavior to the desired condition.

This research observed the result of safety intervention in one of the companies that specialize in providing services for head truck operators, head truck maintenance and lifting, and transport equipment such as Reach Stacker, Forklift and Sky Stacker. According to accident data for the past two years, unsafe worker behavior is the primary cause of work accidents. To reduce unsafe behavior, behavioral observation and intervention (BO&I) using SAFE method (scan, act, follow-up, evaluate) was applied. Behavioral Observation and Intervention (BO&I) is a simplified behavioral safety initiative that companies can use to demonstrate their concern for their employees, teach them safe work practices, and reduce the incidence of at-risk behavior. It is developed by the Workplace Safety and Health Council which aims to promote safe work practices by instilling a sense of mutual ownership in matters of safety among all workers in the company. BO&I aims to reduce the emergence of risky behavior while working, the results of which can reduce incidents, injuries and operational costs that arise due to work accidents (WSH Council, 2014).

The purpose of this research is to enhance the safety of workers by employing the Behavioral Observation and Intervention (BO&I) method and to examine behavioral differences both before and after the intervention. The case focuses on the stages of work that most often cause accidents. The effect of the variables age, length of work, use of PPE, and education on workers' behavior were also analyzed.

2. Methods

2.1. Behavioral Observation and Intervention

The Behavioral Observation and Intervention effort comprises four essential steps: Scan, Act, Follow Up, and Evaluate. The initial phase, Scan, involves identifying safety coaches, creating a behavior observation checklist, and doing observations utilizing the checklist. The second phase, Act, involves recognizing safe behavior, intervening in risky behavior, and providing constructive criticism. The third phase, Follow-up, consists of documenting the at-risk behavior, notifying management, and ensuring management do follow-up actions. The fourth phase, Evaluate, involves repeating the observation, determining whether the at-risk behavior persists, and assessing the effectiveness of the follow-up (WSH Council, 2014).

2.2. Statistical Analysis

2.2.1. t Test

T-tests are statistical tests that compare two groups' means. T-tests are employed when the datasets exhibit a normal distribution and possess unknown variances (Sheskin, 2000)

2.2.2. Trend Analysis Test

The trend is the long-term tendency of data, whether increasing, constant, or decreasing. Trend analysis can be a key factor in successful decision-making on activities (Garbarova and Strezova, 2015). If the plot results of the data obtained tend to be linear, a linear trend model can be used. If the time series data has a movement tendency of increasing or decreasing, a quadratic trend model can be used. If the time series data has a constant upward trend, the exponential trend model can be used.

2.2.3. Binary logistic regression

Binary logistic regression consist of a binary (0,1) response variable (y), and a binary (0,1) predictor (x) (Hilbe, 2015). Binary logistic regression analysis is employed to assess the impact of several predictor variables x_1, x_2, x_3, ..., x_k on the response variable y, which is a binary variable with only two possible values. A binary logistic regression model follows a Bernoulli distribution. The Bernoulli distribution is a distribution of random variables that only has two categories, for example success or failure and profit or loss.

2.3. Implementation of Behavioral Observation and Intervention

2.3.1 Scan

During this phase, a Behavioral Observation Checklist is created as a means to facilitate the observation of worker behavior. Preparation involves the formulation from the work instructions, which are developed through talks with the team. The categories employed pertain to the criteria disseminated by the Workplace Safety and Health Council. The observed categories encompassed the tools and equipment category (including the installation of safety cones, preparation of ring pass keys, screwdrivers, and metal plates), the PPE category (involving the usage of helmets, safety shoes, livestock packs, and safety gloves), and the work process category.

The appointed observer is the head of each group A, B, C, and D. There are three groups that work in a day: shift I from 23.00 to 07.00 WIB, shift II from 07.00 to 15.00 WIB, and shift III from 15.00 to 23.00 WIB. During a single work shift, there is a sole group in operation. Observers are responsible for monitoring the conduct of employees within their team. The team leader, who serves as an observer, is responsible for overseeing a group of 8 workers. An initial study was conducted over a period of 4 days on a sample of 32 workers, divided into 4 groups. Each worker was observed three times. Each worker was observed for a duration of 20-25 minutes.

2.3.2 Act

During this phase, the findings from the first observations are examined to categorize responses into safe and unsafe groups, taking into account the reaction tendencies of all participants. A work step is considered safe if no worker engages in risky activities during the first observations. Work steps are considered unsafe as long as there are workers engaging in risky behavior, even if it's just one worker. Subsequently, interventions are formulated to enhance worker behavior that is categorized as unsafe.

The initial recommended intervention is a safety knowledge refreshment, designed to enhance workers' awareness of occupational hazards and promote discussions on safe work practices. Following that, the intervention consisted of a safety briefing that specifically addressed the task of "coordinating with the operator to neutralize the position of the joystick". This particular stage of work has been identified as the primary factor contributing to work-related accidents. The third recommended intervention takes the shape of an activator, specifically the implementation of safety posters. The subsequent intervention is a motivational approach in the form of a nearmiss card. The purpose of this intervention is to stimulate workers to engage in a competitive manner in order to adhere to safe work practices. Subsequently, one of the workers will be rewarded.

2.3.3 Follow-up

Initial observations were reported to company management. Company management agreed to all recommended interventions, which were subsequently implemented for a duration of 12 weeks.

2.3.4 Evaluate

Concluding observations were conducted following a 12-week intervention. A total of six days were dedicated to conducting final observations, with three observations made for each worker. These observations were conducted according to the predetermined work plan and working hours of each group. Each worker was observed for a duration of 20-25 minutes.

3. Result and Discussion

3.1. Result

3.1.1. Intervention

A delineated Behavioral Observation Checklist was employed for the observations, as detailed in the preceding section. The sample comprised 32 workers divided into four groups supervised by observers A, B, C, and D. Each worker was observed three times for 20 to 25 minutes over three shifts. This approach encompassed all safety practices mandated by the Workplace Safety and Health Council including tools and equipment, personal protective equipment, and work procedures. This observational technique provided a comprehensive and representative sample of worker conduct across time and various working contexts, hence reinforcing the results.

The results of initial observations showed that the average percentage of safe behavior of workers was 56.86%. The results of initial observations are identified and grouped based on safe and unsafe categories. In order to change unsafe behavior towards safe behavior, recommendations will be provided in the form of interventions. The first intervention, an activation intervention, proposed to refresh the safety knowledge of the workers, with the goal of raising their awareness of the risks associated with their task and promoting safe work practices. The safety knowledge refreshment included knowledge of the dangers that may occur at each stage of the twist lock repair task based on existing work instructions, the ways to control these dangers, the importance of using Personal protective equipment (PPE), and safe tips for working in direct contact with the Reach Stacker. The second activation intervention proposed is the installation of safety posters which aim to remind workers about safe working methods. The third intervention is motivational intervention in the form of a nearmiss card which aims to encourage workers to compete to perform safe work practices. One of the workers will receive an award that acts as a supportive intervention. In order to implement the proposed interventions, management was notified and approved. The intervention was implemented for 12 weeks, and the behavioral observation data were collected at the final observation. It was determined that the average safe percentage of workers at the final observation was 78.13%.

3.1.2. t Test Result

The normality test was conducted on both the initial and final observation data for the twist lock reach stacker maintenance task using Kolmogorov-Smirnov. This test was selected for its appropriateness for higher sample sizes and its capacity to deliver a thorough evaluation of data distribution without necessitating binning. Furthermore, it assesses both the form and position of the distribution, rendering it a reliable option for this study. The test results showed a normal distribution of data before the intervention ($p=0.150$) and after the intervention ($p=0.120$), thus the t-test was used to see the difference in the percentage of workers' safe behavior between before the intervention and after the intervention. The average worker’s safe behavior has increased from 56.87% before the intervention to 78.13% after the intervention. The percentage of safe worker behavior after the intervention is higher than before the intervention ($p<0.000$).

3.1.3. Wilcoxon Test

Based on accident data for the last 2 years, the critical work stages in the twist lock reach stacker maintenance task are the sub-task "coordinating with the operator to neutralize the position of the joystick". The results of initial observations showed that the average safe percentage of workers was 3.125%, whereas the final observation results showed that the average safe percentage of workers was 94.792%. The results of the Kolmogorov-Smirnov normality test for 32 workers showed that the data was not normal for both data before the intervention ($p=0.010$) and after the intervention ($p=0.010$). Therefore, the Wilcoxon test was conducted. The result showed that there is a difference in the percentage of workers' safe behavior between before the intervention and after the intervention ($p<0.000$).

3.1.4. Trend Analysis Test

Trend analysis tests were performed on data that had been collected during the 12 weeks of intervention. Based on the results of the trend analysis test using Minitab, it was found that the average percentage of worker-safe behavior tends to increase. The result showed that the intervention that has been implemented has a positive effect on workers' safe behavior.

The equation resulting from the test is $Yt=63.977+0.2495t–0.001375t^2+\epsilon t$. The variable t in the equation denotes the time index, with each unit of t representing a week within the 12-week intervention period. The equation represents the trend of safe behaviour over time, with the coefficients indicating the projected changes in behaviour as time advances. To facilitate a straightforward interpretation of outcomes in percentage terms, particularly for understanding the accuracy of forecasts related to worker safety behaviour, the MAPE (Mean Absolute Percentage Error) value of 0.755245 is employed in the trend data analysis test, indicating a relatively minor average percentage error.

3.1.5. Binary logistic regression

There are four independent variables consisting of age, length of work, use of personal protective equipment, and education. Data for the variables age, length of work, and education were obtained from company data. Meanwhile, data on personal protective equipment use was obtained from observations. The dependent variable was safe (categorized with the number 1) and unsafe behavior (categorized as 0). Worker behavior is categorized as safe if the percentage of safe worker behavior during observation is 80% or above and categorized as unsafe if the percentage of safe worker behavior during observation is below 80% (Geller, 2001).

Using a 95% confidence level, the Chi-square test after intervention showed a p-value of 0.33 which means that all independent variables were not affected dependent variable. Subsequently, the partial test also showed a p-value of 0.959, 0.681, 0.657, 0.999 for age, length of work, PPE use, and education respectively.

3.2. Discussion

The average percentage of workers' safe behavior increased by 21.26% between before and after the intervention. Safety knowledge refreshments, safety posters, nearmiss cards, and rewards were successful in increasing safe behavior in this study. Based on data collected for 12 weeks, there were 107 nearmiss cards reported. One of the employees has received the reward because during the 12 weeks of the program, the total number of nearmiss cards he obtained was zero. Previous research also found the influence of intervention on safety behavior. Management and human intervention contribute to the positive impact of technical intervention (Mazlina Zaira and Hadikusumo, 2017; Luria et al., 2008).

There is a difference in the percentage of safe worker behavior between the initial observation and the final observation. This could be caused by the intervention given to the

respondent. Safety knowledge refreshment increases workers' knowledge of their daily task. The workers become more cautious at work because they have gathered sufficient knowledge to be able to identify hazards (Bahn, 2013, 2012). In addition, safety posters were also used to remind workers to always work safely. With the nearmiss card as a monitoring tool, workers compete to maintain safe work practices. The successful implementation of nearmiss reporting systems may depend on employee willingness to use the system (Su, 2014). As an additional benefit, rewarding workers as a form of appreciation can encourage their enthusiasm to behave safely in order to receive these rewards. Instead of focusing on outcome-based rewards, measurable safety behavior can motivate improved safety performance (Fell-Carlson, 2004).

It is found that in initial observations of the sub-task "Coordinating with the operator to neutralize the joystick position", there was only 1 of 32 workers performed this task correctly. Subsequently, in the final observation, 30 workers performed the task correctly. Intervention was given to workers through appeals for safe work, which contain specific information about the stages of work, which are repeated at every briefing. As a result, workers are more careful and do not violate this stage of work considering the dangers that can arise from skipping this stage can result in serious injury. For example, the worker's hand can become trapped in the twist lock, which automatically locks because the joystick position has not been neutralized.

Based on the trend analysis test, the implementation of the Behavioral Observation & Intervention (BO&I) program will have maximum influence on workers' safe behavior only up to the 91st observation. In other words, companies are expected to be able to provide sustainable innovation in the form of programs that can maintain workers' safe behavioral habits. A good time to provide this program is on the 91st day from the start of the intervention since the percentage of workers' safe behavior starts to decline at the 92nd observation.

Statistical test results showed that there is no significant effect of the age variable on worker behavior before and after the intervention. This result supported the research conducted by (Hikmawan et al., 2013) that found there is no effect of age on work accidents. Previous research has found mixed results regarding the effect of age on productivity. Research conducted by Lallemand and Rycx (2009) found that young workers are significantly more productive than older workers. Whereas Göbel and Zwick (2013) found that the productivity contributions of old workers were high. It is probably because they are more experienced and more skilled at mastering work than younger employees. They are also more motivated and dedicated to their work. Workers who are more productive stay in the workforce longer than those who are less productive (Burtless, 2013). This means that the intervention given during the sample data collection period did not affect the age variable so the results of the data test before and after the intervention on the age variable had no effect on worker behavior even with the intervention. In spite of this, it is inevitable that at the age of 60, physical strength will not support such a high level of enthusiasm and experience, leading to decreased productivity. Milanović et al. (2013) found that there are differences between young and old elderly people due to the reduction of muscle strength. But this opinion does not imply that young or old workers cannot behave safely, and vice versa. The absence of age effect may be due to the supervision provided by the safety officer and team leader from each group have applied the same supervision methods in the work area to old and young workers.

There was no significant effect of PPE use on worker behavior before and after the intervention. The most common causes of twist lock maintenance accidents for the last 2 years were due to workers not complying with standard operational procedures (SOP), not because they were not wearing personal protective equipment. Even though PPE plays an important role in minimizing injuries caused by accidents, in reality, workers feel less comfortable when they use it because it’s not flexible, and they feel more comfortable when they are not wearing it. Safety leaders should regularly evaluate the extent to which workers use personal protective

equipment on the job site, and encourage majority usage by increasing the availability or quality of PPE, offering training, or encouraging positive reinforcement (Olson et al., 2009).

The lack of significant effect of education on worker behavior before and after intervention can be caused by all workers receiving the same treatment from the company such as safety knowledge and briefings. The company also has regulations regarding the minimum educational degree requirement for new employees, who at least have a vocational school diploma. Therefore, it can also be a supporting factor in the absence of influence of educational variables on worker behavior.

4. Conclusion

In an effort to improve workers' safe behavior, behavioral observation and intervention (BO&I) using the SAFE method (scan, act, follow-up, evaluate) was applied. The results of the intervention showed an increase in the percentage of safe worker behavior by 21.26% between before and after the intervention.

The results of the paired t-test on the twist lock maintenance task showed a difference between the percentage of safe behavior of workers before and after the intervention. The results of the Wilcoxon test at the work stage that most often causes accidents, "Coordinating with the operator to neutralize the joystick position", also showed differences in workers' safe behavior before and after the intervention. The results of the binary logistic regression test before and after the intervention showed that there was no effect of the variables age, length of service, use of PPE, and education on safe behavior.

Future research could investigate supplementary factors that influence safe behaviour, including the role of supervision in maintaining safety practices after an intervention, organizational culture, or training methodologies. Additionally, longitudinal studies could evaluate the SAFE technique's long-term efficacy in sustaining enhanced safety behaviours across various operational environments and over time.

Credit authorship contribution

Ervira Fatimatuz Zuhroh: Conceptualization, collecting data, Writing. **Wiediartini**: Conceptualization, Supervision, Writing – review & editing. **Rona Riantini**: Conceptualization, Supervision, Review & editing. **Zulfaidah Ariany**: Supervision, Review & editing.

Declaration of Competing Interest

The authors report no conflict of interest.

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