Towards improving safety performance of transportation maintenance workers through a pre-task safety talk program

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ABSTRACT

Construction workers are more prone to safety hazards compared with workers of other industries according to reports of the U.S. Bureau of Labor Statistics, and transportation maintenance workers are no exception. The nature of the work for this unique audience exposes them to different hazardous conditions, which increases the probability of injuries. As part of a project to improve safety performance for the Kentucky Transportation Cabinet (KYTC) maintenance workers, this study outlines the development of a pre-task safety talk program. By analyzing safety recordable incidents claims of KYTC maintenance employees for a ten-year period between 2005 and 2015, the top leading reasons for claims were determined. The results show twelve leading reasons that were repetitive among ten typical operations for KYTC maintenance workers. Because the majority of the accidents could be avoided if some safety precautions were followed, specific safety practices are suggested according to the nature of the operation and the identified leading reasons. A final product of this project is a pre-task safety tool that workers can use before starting any of their typical work operations. This study identifies the leading reasons behind work-related incidents in highway maintenance and the sizable gap in safety measures targeting this unique sector of the construction industry.

KEYWORDS: Safety education, Safety training, Highway workers

INTRODUCTION

As a unique sector of the construction industry, highway construction and maintenance is characterized by a dangerous work environment. The hazardous nature of this environment is attributed to different reasons including the majority of the work being performed near the passing traffic, large moving construction equipment, and extreme work conditions (Gambatese et al. 2017). Today, maintenance perform different work operations beyond fixing roads pavement and shoulders. Their work operations extend to include snow removal, tree trimming, bush hogging, bridge maintenance, etc. In addition to work-related hazards, the high interaction between maintenance workers and the passing traffic increases their exposure to transportation incidents. This high exposure to traffic hazards drew the focus of safety research, policies, regulations, and practices to the transportation related safety issues leaving work-related hazards with minimal attention.

Hazards, such as falls, trips, slips, contact with electricity, and exposure to poisoning plants are some of the frequent safety issues present to maintenance workers. Hundreds of fatalities and thousands of injuries are the result of highway maintenance work every year in the United States. According to the Bureau of Labor Statistics, there were 2,415 fatalities, not including close calls and survived workers, between 1992 and 2015 among US highway maintenance workers (Bureau of Labor Statistics 2017; Pegula 2004; Pegula 2013). In fact, road workers fatalities rate account for 1.5% to 3% of all work-related fatalities in the US with no descending trend (Gambatese et al. 2017). Kentucky is no exception since recent statistics showed high rate of incidents among its highway maintenance workers (Hecker 2016).

The Kentucky Transportation Cabinet (KYTC), an executive branch agency that is responsible for managing over 27,000 miles of Kentucky roadways, has around 4,800 employees. Around half of KYTC's staff, 2000 employees, are highway maintenance employees who are engaged in different maintenance tasks. Despite the many steps taken by KYTC to improve its employees' safety, recent KYTC safety records show a high rate of incidents. In 2016, KYTC issued a safety report stating that there is a persistent need to address safety of KYTC maintenance employees and adopt a new safety culture (Hecker 2016). Although KYTC was able to achieve its goal of a Total Recordable Incidents rate (TRIR) lower than 5%, a closer look to the statistics show a different reality. Since more than half of KYTC employees are working in an office oriented environment, which means low exposure to hazards, maintenance workers are the most affected employees in these numbers. In fact, the report stated that after a careful examination of the records, the TRIR turned out to be more than 15% as the majority of claims were reported from KYTC maintenance employees, which indicates that there is a persistent need to effective safety measures to improve safety performance and reduce the risk of work-related hazards.

In addition to presenting the design of a pre-task safety educational program to increase safety awareness among KYTC maintenance employees, this paper sheds the light on two main issues; the leading reasons behind work-related incidents in the highway maintenance work and the lack of safety measures targeting the unique workforce within this unique sector of the construction industry.

LITERATURE REVIEW

Safety Awareness

Safety awareness is defined safety as "the state of having knowledge of the risk, hazards, and consequences associated with the construction site" (Musonda and Smallwood 2008). This definition lacks an important aspect of awareness, which is the knowledge of how to avoid, prevent, or at least minimize the risk of hazards. In a study conducted by Sneddon et al. (2006), construction practitioners defined safety awareness as the knowledge about your environment, the inherited hazards within the surroundings area, and the appropriate way to deal with such hazards.

Regardless the exact definition of awareness, Insufficient knowledge and low safety awareness have been reported as major contributors to the poor safety performance of the construction industry. Kozlovska and Strukova (2013) stated that lack of knowledge and unsafe behavior are major causes of work incidents. In fact, there is a significant association between safety awareness and safety performance. Workers with high safety awareness tend to exhibit safer work behaviors. In addition, workers' safety awareness can affect their attitude toward safety, which directly affects safety performance (Garrett and Teizer 2009). Poor attitude toward health and safety on the construction site is often associated with work-related injuries (Kozlovska and Strukova 2013). Therefore, one way to improve safety performance lies in increasing safety knowledge and awareness among workers.

Training is prevalent way to increase safety knowledge. It has been frequently reported that one of the most effective ways to improve safety performance within the construction industry lies in establishing robust education programs for people engaged in planning, management, and execution of construction project and developing strategies to increase their safety awareness (Kozlovska and Strukova 2013). Mohd Khairolden et al. (2008) stated that training and safety educational programs play a significant role in improving safety performance within the construction industry by increasing safety knowledge. However, this does not necessarily mean that all safety training and educational programs result in safety improvement. Today, many construction practitioners pass some safety training programs, yet it is common to see them on the construction site not being able to identify safety hazards or formulate ways to deal with them (Kozlovska and Strukova 2013). In a recent study, Hasanzadeh et al. (2017) found that OSHA ten-hours training does not significantly affect workers' skills in identifying hazards. Therefore, there is a need for effective safety education programs that are specific-specific-to-the task and address the unique hazards present in different type of the construction work.

Safety Education and Training

Safety education is a major element of programs targeting work-related injuries and fatalities (Kinn et al. 2000). However, the effectiveness of educational programs has been the debate of researchers for a while. Researchers have been trying to answer one common question in this regard "Does the Occupational Health and Safety (OHS) training has any beneficial effect on workers (e.g. increase OHS knowledge, improve OHS attitudes, improve OHS behaviors, or protect health)?"(Robson et al. 2012). The

answers for this question depends on the effectiveness of the program. There is no question that an efficient safety education program leads to safety improvements especially if it is designed and presented in a way that increases workers understanding, and evaluated based on true assessment of feedback and performance results. In a study to evaluate the effectiveness of safety orientation and training programs targeting plumbers and pipefitters, Kinn et al. (2000) concluded that proper safety education could reduce the risk for injuries in construction workers after they found that the rate of work-related injuries among workers who had safety orientation is significantly lower than the rate of injuries among workers without orientations. After a meta-analysis of selected safety education and training programs between 2007 and 2014, Ricci et al. (2016) concluded that there is significant effect for safety training and education programs on workers safety attitude, behavior, and knowledge.

Safety education effectiveness relies on many different factors, but a well-designed safety program should make incidents more predictable, should be developed based on true evaluation of the need, and should emphasize safe work practices (Vredenburgh 2002). In addition to the design consideration, the communication media of the safety education material is a crucial element of any program. One of the most frequent difficulties found within safety education and training programs is the ability of participants to recall and remember the program materials (Ebbinghaus 2013; Garrett and Teizer 2009). Therefore, the content of any safety education program should be communicated in an intuitive and easy to understand way to ensure the easiness for participant to recall the content when needed. Electronic learning (E-learning) communication was reported as one of the effective means to deliver safety materials in educational and training programs. Ricci et al. (2016) found that E-learning methods, the use of technological tools in learning, to be one of the most efficient methods, compared with other methods, such as classroom training, that can be used in safety educational and training programs when it comes to changing participants' attitudes or increasing their knowledge. Based on what has been reviewed, it can be concluded that an effective safety education program requires true assessment of the need, focus on safe work practices, and intuitive communication that facilitates content understanding.

METHODOLOGY

To accomplish the study objectives, a collection and in-depth qualitative analysis of recordable incidents records of KYTC maintenance employees were conducted to categorize the frequent safety hazards according to KYTC typical maintenance operations. This is followed by assigning effective safety practices to address the potential hazards within each maintenance operation.

Data Collection

Classified according to the National Council of Compensation Insurance (NCCI) code, the recordable incidents data used in this study was collected from KYTC for a ten-year period between 2005 and 2015. A total of 3,876 claims of KYTC maintenance workers only were recorded using Microsoft Excel. The data included variety of information, such as the claim number, NCCI causation code, incident

location, incident time, incident description, claimant profile. Few records of the data missed essential information and therefore were removed. Data included in the analysis consisted of 3500 records. Detecting lack of information in some of data helped in providing recommendations to improve incident recording and reporting techniques.

Data Categorization and Analysis

To ensure a careful assessment of data and identify the frequent incidents and leading reasons behind them, and to suggest the effective practices to address the potential frequent hazards, the analysis of the data was divided to three stages. The first stage included the classification of the incidents according to typical work operations. The second stage was in-depth analyses for the classified data to identify the top leading reasons behind the incidents within each work operation. The final stage included suggesting the appropriate safety practices to address the identified hazards and prevent or minimize the risk of them.

Stage I: Incidents Classification

KYTC maintenance employees perform about 17 maintenance work operations according to KYTC Field Operation Guide for Maintenance. The incidents data was recorded in cooperation with the Risk Management Services Company. Their data collection system did not include a place for the maintenance work operation. Therefore, the objective of this stage is to classify incidents data according to the 17 maintenance operations. This classification helped in converting the qualitative data to quantitative data that can be counted to obtain the frequency of incidents within each maintenance operation. The classification was performed according to the available information in the data and the 17 maintenance work operations. The cause of incident and incident description were major drivers of this classification since the information available under these terms enabled the identification of which work operation does the incident belong to.

As mentioned above, some information within the recorded data were missing especially the information associated with the maintenance work operation. In addition, the criteria of reporting incidents did not count for work operation. This lack of accuracy in recording and incident reporting resulted in eliminating seven of the maintenance operations since the available information within the recorded data align with only ten of the 17 typical maintenance operations. Once again, this issue highlights the need for more robust and accurate reporting and data collection methods to ensure the accuracy of future decisions regarding safety improvements. Figure 1 shows the type and frequency of incidents within each of the ten identified operations. As shown in Figure 1, the distribution of hazards is consistent with the nature of each work operation. For example, slips and trips are dominant hazards in snow removal operation while cuts, punctures, and scrape are dominant in guardrail maintenance. Such hazards distribution emphasizes the need for safety measures that address each work operation. The available general safety training, such as OSHA ten-hours training, does not fulfill this need. Therefore, providing frequent hazards within each operation in this safety program will help workers and improve their skills in hazard recognition. This categorization stage paved the way for further analysis in the second stage.

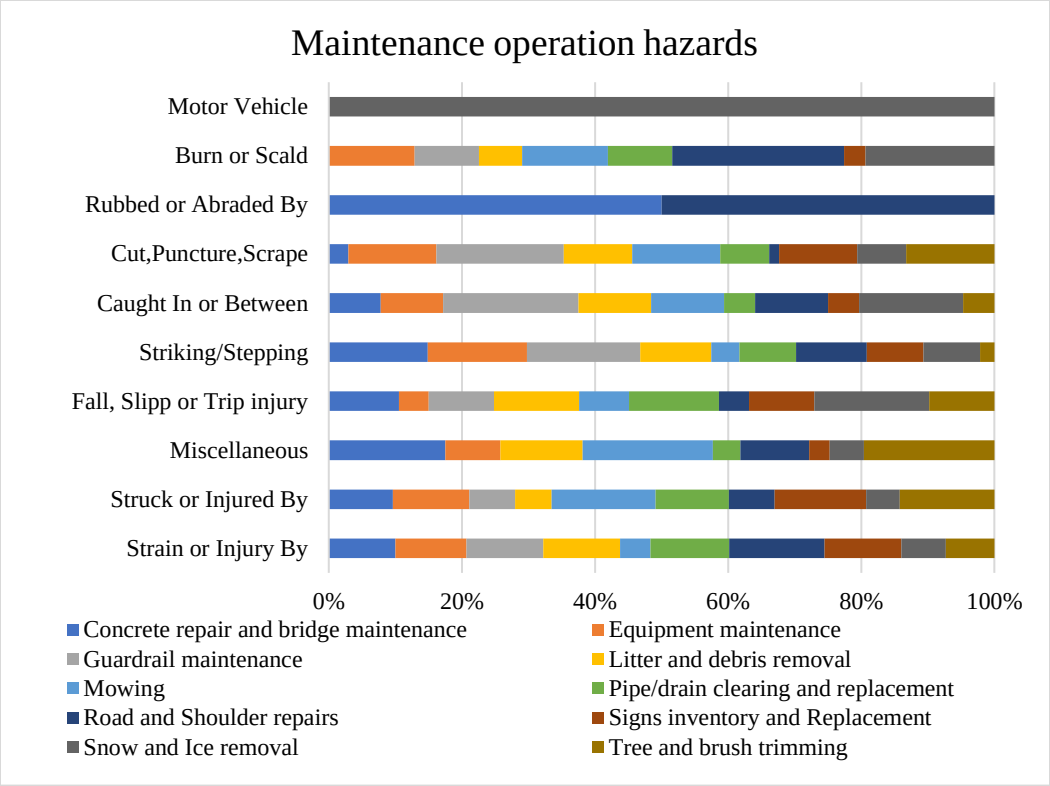

Figure 1. Hazards and Frequency within KYTC Selected Operations

Stage II: Leading Reasons Identification

Aligning hazards according to maintenance operations facilitated the identification of the most frequent causes that led to the hazards identified in the first phase. In the raw data, claims were categorized according to the NCCI code. This classification included some details that were unnecessary for the purpose of this study. For example, the code classification included terms, such as lifting, object being lifted, carrying, or holding, etc. in the incident cause description. These terms referred to the same scenario, worker engaged in a lifting activity, that often leads to the same results. Therefore, such terms were combined since they represent similar causes that often lead to similar injuries. Within each of the selected operation, 5 to 6 of the most frequent cited causes were identified. For all the ten-identified operations, 12 causes were collectively identified as the most frequent. Table 1 presents these 12 causes and the average annual frequency for the ten-year period between 2005 and 2015. These causes are the most repetitive within the ten maintenance operations. Some of the causes, such as lifting, appear in each of the operations. In fact, lifting ranks at the top of the list as the most frequent cause of incident within all of the selected operations.

Some of the identified causes were found to be associated with human factors and ergonomics. For example, falling from different level was mostly associated with two scenarios, such as exiting a work vehicle or getting in and out of a truck bed. Such scenarios are directly affected by human factors, such as expectancy and perception (Cohen 2003; Hsiao 2014; Zohar 1978). This issue is a critical highlight of this study

since there is a lack of practices that address human factors and ergonomics in such scenarios. For example, OSHA requires fall protection only for people working at heights greater than 6 feet. This study highlights the need to address the human factors and ergonomics aspect that have not been covered by the available safety measures. Addressing such factors could take place in earlier phases, such as the design phase.

Table 1. Top Frequent Incident Causes

Top Frequent incident causes	Frequency Per year	Top Frequent incident causes	Frequency Per year
1- Object being lifted	64.1	2- Falling or flying objects	31.3
3- Fall from different level	23.9	4- Hand tool or machine in use	18.9
5- Pushing or pulling	14.9	6- Foreign matter in the eye	14.3
7- Fall on ice or wet floor	14.1	8- Chemicals, liquids, or vapors	11.5
9- Vehicle upset	10.6	10- Animal or insect	9.9
11- Stationary or sharp objects	6.2	12- Hot object and temperature extreme	4.7

Stage III: Best Practices Identification

Due to the uniqueness of each state transportation system, safety issues differ from state to state accordingly. Therefore, each state develops its own safety programs to address their safety issues. In addition, federal standards and regulations do not offer much to address the needs found in this study. This lack of federal practices might be reasonable since there are not much practices applicable in every state. In other words, the uniqueness of each state transportation system does not leave enough room for federal practices regarding highway construction and maintenance workers. As a result, there is a significant lack of knowledge in standardized effective safety practices applicable to highway maintenance operations. This is particularly true when it comes to safety issues associated with human factors and ergonomics. To address this issue and to select effective safety practices, the following four criteria were followed to identify safety best practices:

1- Academic safety resources,
2- Government regulations and standards,
3- Operation specific practices addressing specific frequent safety issues, and
4- Safety practices from industry guidance.

To collect effective safety practices and according to the criteria above, several resources were identified including the following:

- 29 CFR 1926 OSHA regulations;
- The National Institute for Occupational Safety and Health (NIOSH) standards;

- OSHA ergonomics E tool;
- Construction solutions by Center for Construction Research and Training (CPWR);
- Roadway Safety training program;
- Other States employees' health manuals;
- Safety tool kits of Kansas State University;
- Safety tool kits from University of New Hampshire;
- Safety tool kits from University of Washington, and other resources.

After a careful review of the selected resources, safety practices were collected to address the previously identified causes in stage II. The intention of the safety program in this study is not to use it as a training program of the safety practices. Instead, it should be designed to present practices in a quick, intuitive, easy to understand, and fundamentally complete manner that ensure effective use of the program in a short time period. Considering this design concept, the identified practices were consolidated, and the details were condensed to abbreviate the presentation within the safety program.

THE DESIGN PHASE AND FINAL PRODUCT

The main objective and the final product of this study is a safety educational program that KYTC maintenance crews can use prior to the workday's planned operation to review potential hazards present and mitigation measures to address them. The material presented in the program can be used then by safety coordinators, foremen, and/or supervisor to prepare for a safety talk prior to the start of the workday to make maintenance workers aware of the potential work hazards within their work operation, the frequent reasons behind these hazards, and the effective safety practices to mitigate or prevent the risk of such hazards. Therefore, the program was designed with the following considerations in mind:

1- The program should be simple and intuitive to use and understand;

2- It should be quick to complete;

3- It should address the top frequent potential hazards;

4- It should be expandable to all maintenance operations; and

5- It should be updatable so it can be improved based on safety performance.

Due to the easiness of use and access for KYTC employees, Microsoft Excel was used to design the program through macro-enabled spreadsheets. Incompatibility and platform accessibility concerns impeded the utilization of mobile device platform and web-based applications in designing the program. In addition, to ensure the simplicity of the program, the number of buttons was minimized.

The program platform consists of four main sections or levels. The first section represents an introductory sheet that contains user instructions. The second section of the program presents a statistical chart of the overall historical injuries of KYTC maintenance employees during the ten-year period between 2005 and 2015. This

section also contains ten buttons, representing the ten selected maintenance operations, that, if clicked, take the user to the third. The third section includes a statistical summary of previous injuries of KYTC maintenance workers and the associated top frequent incident causes within each operation. The last section of the program introduces different frequent examples of past work incidents for each of the leading reasons and the suggested safety practices to mitigate the potential risk associated with them. These sections are designed to minimize the efforts of users in using the program and understanding the content. Some pictorial demonstrations were used to help users understand the content, and to minimize the usage time of the program. For detailed description and pictorial demonstration of the program and its functionality, see Al-shabbani et al. (2017).

CONCLUSION

Highway maintenance work is dangerous, yet has received little attention on practical, specific guidance on increasing safe work behaviors. By analyzing historical incident records for maintenance workers in Kentucky, the authors have provided guidance and a practical pre-task briefing tool to improve safety performance. Incidents were categorized, underlying causes identified, and best practices to improve outcomes provided. In addition to identifying the leading reasons behind hazards in highway maintenance, this study sheds the light on the lack of safety standards, policies, regulations, and practices targeting this unique sector of the construction industry that is characterized with poor safety performance. Future work in this area will include an assessment of the effectiveness of this safety program.

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