

Analysis of Occupational Injuries in the Mechanical Contracting Industry of Southern Nevada

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In the United States, more than three million non-fatal workplace injuries were recorded in 2014. The injury rate of Nevada is above the average rate of national level. This paper analyzes injuries and illness rate of mechanical contracting industry located in southern Nevada. It also determines the impact of safety training classes and use of personal protection equipment to reduce these injuries. To obtain the injury data a questionnaire survey was conducted with mechanical contractors working in southern Nevada in 2009. The format of the questionnaire used to collect these data are similar to the one used by the United States Bureau of Labor Statistics. The results show that the injury rate for larger mechanical contractors is significantly lower than the injury rate for smaller mechanical contractors. Results also show that sprains and strains are the major injury types. The study could not find significant association between Occupational Safety and Health Administration safety training and injury rates.

Key Words: Injuries, Mechanical Contractor, Southern Nevada.

Introduction

The Bureau of Labor Statistics (BLS) recorded more than three million non-fatal occupational injuries in the United States (BLS, 2014). The BLS data showed that the overall national level of occupational injuries rate of 2013 decreased compared to the rate of 2012. However, the occupational injuries rate of specialty trade contractor increased during that period. As per BLS, the injury rate is calculated using equation 1 (BLS 2013). In the injury rate equation 1, the number 200,000 hour is equivalent of 100 workers working 40 hours per week for 50 weeks per year (BLS 2015).

$$\text{Injury Rate} = \frac{\text{Number of injuries and illness}}{\text{Employee hours worked}} \text{x } 200{,}000 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Injuries and illnesses in the United States (U.S.) construction industry remain at alarmingly high rates. In 2007 and 2008, employment in the U.S. private industries was approximately 6.69% of the total employment. However, the injuries and illnesses in the private industries was approximately 9.12% of total injuries and illnesses (OSHA, 2010). In addition to this, the fatalities in the private construction industries were approximately 20.2% of total fatalities in the private industries (BLS, 2009b). In Nevada, the injuries and illnesses in private construction industries was above the national level. In 2007 and 2008, employment in the Nevada private construction industries was approximately 11.7% of the entire Nevada private industries. However, injuries and illnesses in the construction industries were 18.36% of total injuries and illnesses in the private industries. Moreover, the fatalities were approximately 30.49% of total fatalities in the private industry (BLS, 2009b).

Regarding the information on injuries, illnesses, and fatalities in the construction industry, the BLS data only reflects non-fatal Occupational Safety and Health Administration (OSHA) recordable injuries and illnesses. OSHA defines a recordable work-related injury and illness as one that keeps an employee away from working a full shift, or prevents an employee from performing all of his or her routine job functions at least once a week. Restricted work activity limited to the day of injury does not make the case recordable (OSHA, 2010). This definition excludes minor injuries sustained by construction workers that are not as serious, and do not result in lost time, or days away from

work. This paper includes OSHA recordable injuries and illnesses and minor injuries, which were not reported. All the data were collected directly from the mechanical contractors.

The construction industry encompasses a wide range of agencies, trades, and disciplines. The BLS breaks down the construction industry into three categories: 1) the construction of buildings; 2) heavy and civil engineering construction; and 3) specialty trade contractors. Under specialty trade contractors, the BLS includes the category of building equipment contractors, under which are the following categories: 1) Electrical contractors; 2) Plumbing, heating, and air-conditioning contractors; and 3) Other building equipment contractors. This study focuses on the second and third categories of plumbers, heating, and air-conditioning contractors, and other building equipment contractors.

Literature Review

Mechanical Contracting

BLS (2009a) presented the non-fatal injuries and illnesses occurred in mechanical contracting. In Nevada, between 2006 and 2007, an average of 2,860 non-fatal occupational injuries and illnesses occurred. Of these injuries, 97.35% were sustained by males; 34% were sustained by workers between the ages of 25 to 34 and 21.35% were sustained by workers between the ages of 35 to 44; 47.7% were sustained by Hispanic workers; and 28.35% were sustained by White workers. This data provided an insight into occupational injury and illness trends in mechanical contracting.

Fredericks et al. (2003) studied the source and cause of injuries as well as workers' body parts affected by the injuries for the 14 Michigan mechanical contractors. The authors also identified that for Michigan contractors, sprains and strains were the common injuries and illnesses. The body part most frequently affected was the trunk, more specifically the back. The most common source of injuries and illnesses was parts and materials, while the most frequent cause of fatalities was falls. The number of employees in each company varied from 10 to 700 workers. The authors found eye injuries, which were frequently caused by metal shavings due to grinding and welding metals. Most injuries and illnesses to the fingers and hands were attributed to sheet metal cuts. The most common back injuries and illnesses were due to handling pipes and valves.

Hinze and Gambatese (2003) examined factors that influence safety performance of specialty contractors. They also explored the factors that helped to prevent occupational injuries and illnesses in construction. They obtained data from mechanical contracting on injuries and illnesses by surveys. They mailed the first survey to Nevada specialty contractors; they sent the second survey to the roofing, sheet metal, and air-conditioning contractors association; and they sent the third survey to large mechanical contractors throughout the nation. Forty-six Nevada specialty contractors, 35 roofing contractors, and 39 large mechanical contractors responded to the survey. The authors found that the median injury rate for specialty contractors in Nevada was 11.46, while the industry average of the OSHA recordable injuries in 2000 was 8.5. The roofing contractor's median injury rate was 12.21 compared to OSHA's 10.9. The authors also found that the median injury rate for mechanical contractors was 9.59 compared to the industry average of the OSHA recordable injuries for plumbing, heating, and air-conditioning of 9.2. The result also showed that for Nevada specialty contractors, the injury rates were lower with the larger firms.

Common Construction Contracting

Hinze (1997) studied regarding the injury rates in various types of companies and determined a correlation between injury rates and company characteristics. The authors found that 90% of private company had a better safety record as compared to public company. The authors also found that the injury rate increases as the firm size increases to some limit then, the injury rate leveled off and did not increase with firm size.

Hinze et al. (2006) analyzed 40,000 construction workers' injury data. The result showed that the most frequent injuries were lacerations to fingers and hands (23.87%), lumbar spine injuries including back pain (12.75%), upper extremity injuries including fingers and hand concussions, wrist and finger sprains, joint pain, and crushing injuries (11.37%), and eye injuries involving abrasions, inflammation, or scratches due to foreign bodies (10.94%). Males

composed 89% of the workforce, suffered higher rates of lacerations, eye injuries, and fractures than the female workers. However, female workers were more likely to suffer upper extremity injuries. The authors cautioned that these findings might be attributed to differences in craft functions. The authors also noted interesting correlations between injuries and age. The authors found that the younger workers were more likely to have lacerations and eye injuries than older workers, in particular men under the age of 35 years.

Everett (1999) examined overexertion injuries which are the single largest classification of injury in the field of construction. By breaking down 65 construction activities into its constituent tasks and analyzing that task for seven generic risk factors for overexertion, the study found that all construction activities had high overexertion injuries rate. The seven risk factors employed by this study are repetitive exertions, static exertions, forceful exertions, localized mechanical stresses, posture stresses, low temperature, and vibration. The term "overexertion" referred to cumulative trauma disorders, repetitive motion injuries, repetitive stress injuries, musculoskeletal disorders, and ergonomic injuries. Although there was a discrepancy between labor groups and contractor groups about the seriousness of overexertion injuries, there was sufficient data to show the impact of gender and age on overexertion injuries.

Objectives of the Study

The main objectives of this study are to identify and analyze injuries and illnesses trends among various mechanical contractors of southern Nevada. Also, the injury rate of the workers of southern Nevada mechanical contractors is to compare with national BLS data. In addition, another objective is to find association between Occupational Safety and Health Administration safety training and injury rates.

Study Methodology

This paper collected the injury data of mechanical contractors who specialize in the four categories. Those categories were: 1) plumbing; 2) heating, ventilating, and air-conditioning installers; 3) utilities installers; and 4) others, such as fire protection systems installers. To collect the injury data, a questionnaire was designed, which grouped respondents by company characteristics as well as worker characteristics. The company characteristics defined each respondent by type of contractor, specialty work performed, company annual revenue, and number of workers. The worker characteristics consist of gender, ethnicity, and age. The questionnaire collected data related to the worker characteristics as well as the number of injuries per company defined by the BLS dataset. Moreover, the questionnaire collected the severity of the injuries such as minor injuries and injuries resulting in hospitalization or death. The nature of injuries, body parts affected, and causes of injuries were also collected. Upon reviewing existing scholarly literature on occupational injuries in construction, eye injuries and fall injuries stood out as prominent injuries that required special attention, therefore, questions regarding eye injuries with and without the use of eye protection, and fall injuries without the use of personal protective equipment, were included. Finally, questions related to causes of injuries, actions taken, and the OSHA safety training taken by the injured employees, were also included in the questionnaire.

Respondents were limited to mechanical contractors working in southern Nevada, specifically in the cities of Las Vegas and Henderson. A total of 71 mechanical contractors were identified and invited to complete the questionnaire. The mechanical contractors were selected from a list provided by the Mechanical Contractors Association of America (MCAA) web-page directory, the Associated General Contractors (Las Vegas Chapter), and the United Association (UA) Local 525 web-page directory. Supplemental contractors were found using the Google database search for the cities of Las Vegas, and Henderson, Nevada.

Results

Descriptive analysis was conducted to analyze the injury data. Analysis of Variance (ANOVA) test was conducted to determine a statistical difference between injury rates among various categories. The Pearson Correlation test was conducted to determine the association between injury rate and OSHA safety training.

The data received from 27 (38.03% response rate) mechanical contractors reported a total 2,522 employees and 224 injuries. Among the 27 responded contractors, five specialized in plumbing systems, 10 specialized in Heating, Ventilation, and Air Conditioning (HVAC) systems, and 12 specialized in both plumbing and HVAC systems. The result of the responses is presented in eight sub-sections. They were: 1) employer and employee characteristics, 2) nature of injury and illness, 3) injury rate by various categories, 4) body parts affected by injuries, 5) causes of eye injuries, 6) causes of injuries and illness, 7) party at fault, and association between injury rate and OSHA safety training.

Employer and Employee Characteristics

To compare injury rates, the dataset was subdivided into six major categories based on employer and employee characteristics. The six categories were: annual revenue, age of the employees, ethnicity of the employees, type of specialty work, number of employees, and type of contractor. The annual revenue of the contractors ranged from $0.18 million to $425 million. The half of the respondents had annual revenues below $5 million and half had $5 million and above. The data analysis result showed that the number of companies who had majority of workers over the age of 35 years were two times than that of companies with majority of workers aged less than 35 years. Regarding the ethnicity of employees, slightly more than half of the companies had more than 50% of white staff. For the type of specialty work, 44%, 37%, and 19% of contractors had specialty in plumbing/HVAC, in HVAC, and in plumbing works respectively. Out of 27 respondents, 59% of the companies had more than equal to 22 employees. The majority of companies contracted commercial/residential work (44%), followed by commercial work (30%), and finally commercial/industrial work (26%).

Nature of Injury and Illness

Data regarding the nature of injury and illness was analyzed for the six major categories. Figure 1 shows the result of the responses. Sprains and strains was the obvious dominant nature of injury across all categories. The overall average percentage of sprains and strains was around 31%. The most significant discrepancy of nature of injuries and illnesses were in reference to revenue and number of staff in a company. The results showed that companies with annual revenues less than $5 million, and a staff less than 22 employees reported more injuries.

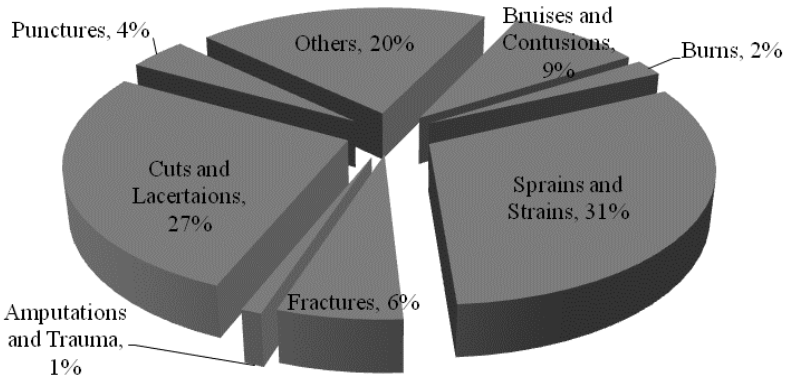

Figure 1: Nature of Injury.

Injury Rate by Various Categories

The average injury rate calculated for six categories and their groups. Table 1 shows the result of responses. There were 224 reported injuries in 2009 for these 27 mechanical contractors. The average injury rate was found to be 13.20, which is little higher than 10.2 reported by BLS for 2008 in the category of specialty trade contractors. The

top three categories which produced the highest injury rate were companies which had less than 5 million annual revenue, plumbing specialty work, and companies which had less than 22 employees.

Table 1

Injury rate by various categories

Categories	Groups	No. of respondents	No. of employees	No. of injuries	Injury rate
Annual Revenue	<$5 Million	6	61	14	20.71
	≥$5 Million	6	1419	84	6.28
Age of the Employee	<35 Yrs	7	185	13	10.66
	≥35 Yrs	15	778	126	17.51
Ethnicity of Employee	<50% White	8	266	27	15.62
	≥50% White	15	727	113	14.37
Type of Specialty Work	Plumb/HVAC	12	1869	159	10.22
	Plumbing	5	208	29	21.52
	HVAC	10	445	36	12.62
Number of Employees	<22 Emplys	11	123	24	20.39
	≥22 Emplys	16	2399	200	8.26
Type of Contractor	Comm/Resid	12	454	43	16.01
	Commercial	8	609	94	14.65
	Comm/Indst	7	1459	87	6.72
Total		27	2522	224	13.20

Body Parts Affected by Injuries

This study found that construction workers on site duty for commercial projects were most likely to injure their hands and wrists. They were also most likely to have back, eye, and finger injuries. Figure 2 shows a distribution of body parts affected by injuries for the mechanical contractors. This figure presents that around 18% injuries were at hand and wrist part of body and it was the most frequent injuries followed by 14% back injuries. Eye and Fingers were also the body parts those frequently injured in mechanical contracting and they contributed 13% in each of parts separately.

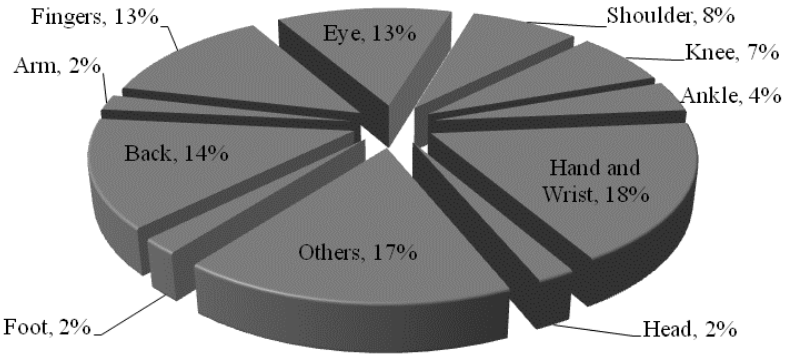

Figure 2: Body Parts Affected.

Causes of Eye Injuries

Results showed that eye injuries occurred while were 29 (16.48%) eye injuries out of the total 176 injuries. Plumbing/HVAC specialists and commercial contractors reported large number of eye injuries. They reported that foreign debris was the main cause of most eye injuries. Whereas, for HVAC specialists and commercial/residential contractors, the foreign debris caused the least number of eye injuries. These participants were also asked for the

occurrence of eye injuries while wearing eye protection. The data analysis showed that employees received eye injuries whether they were wearing or not wearing glasses or goggles. However, there was no single evident of eye injury when face masks were used. The data showed that out of 29 eye injuries, 59% injuries was while employees used glasses; 34% injuries was while they did not wear any eye protection; and 7% injuries was while wearing goggles. This result indicated that the face masks provided the best eye protections and if not simply wearing goggles also helped to reduce the eye injuries.

Causes of Injuries and Illness

Eleven major causes of injuries and illnesses were found. Figure 4 shows the summary of responses. The main three significant causes of injuries and illnesses were parts and materials, contact with objects and hand tools, and machinery and falls. The most overwhelming cause of injuries was parts and materials (39%). Hand tool-caused injuries occurred more frequently in companies with annual revenues lower than $5 million, and less than 22 employees by 27% and 18% respectively. Plumbing and HVAC specialists reported almost twice the average of plumbing/HVAC specialists who reported below average. Commercial and commercial/residential contractors reported above the average injuries and the commercial/industrial contractors reported below the average injuries level. Result also showed that companies where non-whites were the majority and the staff were under the age of 35 years reported almost 30% more injuries caused by contact with objects and equipment.

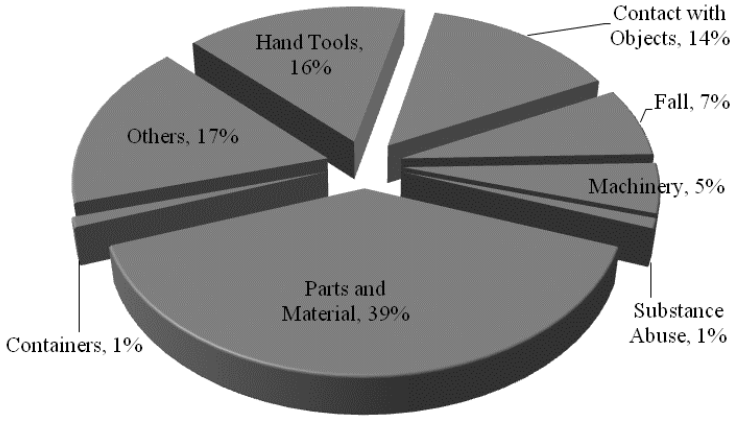

Figure 3: Causes of injuries and illness.

Party at Fault

The respondents were also asked about the party at fault. Around 35% of respondents mentioned that the main party at fault was employer, 36% respondents stated that they don't know, 25% respondent stated that it was the fault of employees, and 4% responded that neither party was at fault. Specifically, the companies having more than 22 employees stated that the injuries were because of employers whereas the smaller companies having less employees mentioned that employees were at fault for most injuries. This paper also studied on the actions taken by the employer to the injured employees. Inside 27 mechanical contractors, around 92% of employees were already OSHA trained; however, in most cases, the injured employees were again enrolled to a safety training course. Particularly, the plumbing specialty reported that more than one-third of their employees were fired as a result of fault for an injury.

Association between Inury Rate and OSHA Safety Training

Pearson Correlation Test was conducted to determine the association between injury rate and OSHA safety training course taken by the employees. The test was conducted to determine whether the correlation coefficient is statistically significant at alpha level 0.05. Result showed that the correlation coefficient was negative, which means the injury rate was higher for employers which have fewer employees with OSHA safety training; the result was not statistically significant at alpha level 0.05.

Conclusions and Recommendations

This paper calculated worker injury rate of mechanical contractors who specialize in plumbing; heating, ventilating, and air-conditioning (HVAC) installers; utilities installers; and others; such as fire protection systems installers. The injury rate analysis implied that the company with higher annual revenue and higher number of employees had lower injury rate. One of the possible reasons for this could be bigger companies tended to have better safety training than the smaller companies.

Regarding the nature of injuries, data implied that hand and wrist injuries were predominant in mechanical contracting. The reason may be attributed to the fact that mechanical contractor worked more with hand tools and handle smaller objects that would have more likely injured their hands, fingers, wrists, and shoulders.

The data also suggested that more than one-in-four injuries were cuts and lacerations for mechanical contractors, which was much more than the Bureau of Labor Statistics (BLS) data (Bureau 2009a). Ethnicity had no impact on these types of injuries, but regarding the employees' age, more experienced workers (over the age of 35 years) had higher injury rates.

The data supported that there were more eye injuries among mechanical contractors' employees than construction workers. That was may be the mechanical employees were involved more in cutting material, which had more potential to ricochet into the eye. The result implied that foreign debris was the number one cause of eye injuries. The rates of eye injury were high regardless of the types of specialty works performed, and the types of contracts. Interestingly enough, result implied that more eye injuries occurred while wearing glasses than not wearing any eye protection at all; however, only a few percent of eye injuries occurred while wearing goggles. The possible reason could be debris may have ability to ricochet behind protective eye wear and make its way into the eye; therefore, glasses only provided a one-dimensional form of protection.

The data implied that varying tasks and exposure to tools and materials had a correlation with the types of injuries and body parts affected. Falls or overexertion were prevalent in construction (Everett, 1999; Shrestha et al., 2015), but in mechanical contracting, parts, materials, contact with objects, and hand tools were the main culprits. Results implied that two-out-of-five injuries were caused by parts and materials. This data was consistent with the high rate of cuts and injuries to the fingers and hands. Mechanical contractors handled hazardous and sharp materials and were exposed to work environments with pointy sharp edges and corners that easily pierced through shoulders upon contact. Majority of work tasks with a hand tool may have yielded high percentage of wrist injuries.

The respondents reported that more than one-third of the injuries were attributed to employer fault. The majority of employer fault were reported by plumbing/HVAC specialists and commercial/industrial contractors. Employee age was not a factor in the attribution of fault, but companies with a staff more than 22 employees either didn't know who was at fault or blamed the employee, whereas smaller staffed companies either didn't know or blamed the employer. In most cases, when the employee was found to be at fault, that employee was enrolled in a safety training course. Only 20% of the time of injury, the employees were punished with suspension.

Finally, the result also implied that nine-out-of-ten employees had taken the Organizational Safety and Health Administration (OSHA) safety courses. HVAC specialists had comparatively slightly lower number of employees, who had taken this course, and commercial/residential contractors responded with similar numbers. Companies with more number of staff had more employees who had taken OSHA safety course than companies with smaller number of staff. Every category reported over half of their staff had taken the OSHA safety course. The correlation test result implied that although there was a negative correlation between injury rate and percentages of employees who has taken OSHA training, the correlation was not statistically significant.

It is possible to expand safety courses to include and focus on those tasks that are specifically hazardous to employees in the field of mechanical contracting. It is recommended that individual companies assess the type of work being contracted and the type of specialists on their staff in order to equip those workers with the tools and knowledge necessary to stay safe. Age and experience of worker are the factors that could affect injury rate. Therefore, it would behoove a company to pair seasoned and experienced onsite workers with younger, less

experienced workers. Seasoned workers would be able to identify hazardous situations before they lead to injury or teach less experienced workers how to look out for these hazardous situations. Protective hand wear should be considered, especially the type that protect against cuts. Employees should learn better techniques when using hand tools, which also involve knowing when to take a break and not overexert the wrist, in order to avoid those common types of injuries. Although this study found occurrence of a few eye injuries while wearing goggles, it is recommended that protective eyewear be worn, especially that protects the entire eye and does not facilitate injuries caused by flying debris.

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References

Bureau of Labor Statistics. (2015). *How to compute a firm's incidence rate for safety management.* [WWW document]. URL http:// http://www.bls.gov/iif/osheval.htm

Bureau of Labor Statistics. (2014). *Employer-related workplace injuries and illnesses – 2013, U.S. Dept. of Labor, Bureau of Labor Statistics.* [WWW document]. URL http://www.bls.gov/news.release/pdf/osh.pdf

Bureau of Labor Statistics. (2013). How to compute a firm's incidence rate for safety management. [WWW document]. URL http://www.bls.gov/iif/osheval.htm

Bureau of Labor Statistics. (2009a). Health and Safety Statistics, U.S. Dept. of Labor, Bureau of Labor Statistics. [WWW document]. URL http://www.bls.gov/

Bureau of Labor Statistics. (2009b). Industry at a Glance, U.S. Dept. of Labor, Bureau of Statistics. [WWW document]. URL http://www.bls.gov/iag/

Everett, J. (1999). Overexertion injuries in construction. *Journal of Construction Engineering and Management*, ASCE, 125(2), 109-114.

Fredericks, T., Abudayyeh, O., Palmquist, M., & Torres, H. (2003). Mechanical contracting safety issues. *Journal of Construction Engineering and Management*, ASCE, 128(2), 186-193.

Hinze, J. (1997). *Construction safety*, Prentice-Hall, Upper Saddle River, N.J.

Hinze, J., Devenport, J., & Giang, G. (2006). Analysis of construction worker injuries that do not result in lost time. *Journal of Construction Engineering and Management*, ASCE, 132(3), 321-326.

Hinze, J., & Gambatese, J. (2003). Factors that influence safety performance of specialty contractors. *Journal of Construction Engineering and Management*, ASCE, 129(2), 159-164.

OSHA. (2010). The OSHA Recordkeeping Handbook, U.S. Dept. of Labor, Occupational Safety & Health Administration. [WWW document]. URL https://www.osha.gov/Publications/recordkeeping/

Shrestha, K., Shrestha, P.P., Bajracharya, D., & Yfantis, E.A. (2015). Hard hat detection for construction safety visualization. *Journal of Construction Engineering*. DOI: 10.1155/2015/721380