Session No. 7160

Determination of Weighting Factors in the Improvement of Incident Rate Analysis

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Introduction

The primary objective of this research is to incorporate weighting factors into a new statistic measure for the determination of the "traditional" OSHA recordable incident rate. In this work, it was suggested that the combination of the incident rate and lost workday rate provided a clearer picture of the true impact of recordable cases of an organization. Currently, in the United States, the Occupational Safety and Health Administration (OSHA) is the federal body whose purpose is "to assure so far as possible every man and woman in the nation safe and healthful working conditions and preserve our human resources."

Incident rates allow for the standardization in the interpretation of frequency, severity of injuries, and illnesses across a designated establishment and within a specified time period. This standardization enables communication and comparison of incident rates across differing establishments, which can be defined as business units within a company, companies, industries, and government agencies. Each establishment utilizes incident rates in differing manners. Companies may use them as the main indicator of safety performance within an establishment, while industries and government agencies aggregate data to industry, state, and national levels to derive descriptive statistics and overall trends. Until recently, the traditional method of computation of the OSHA recordable incident rate has been based on the continuous use of the standard OSHA calculation methodology.

This use of data as a source for safety performance indication is driven by the requirement of the Occupational and Safety Health Act of 1970 (OSHAct), Section 24, where it mandates the Secretary of Labor to "develop and maintain an effective program of collection, compilation, and analysis of occupational safety and health statistics." As part of this duty, OSHA gathers data on occupational injuries and fatalities. This data is recorded and different measures are used to analyze that data and present it in easily understood forms. Some of these measures include the recordable incident rate, lost time case rate, lost workday rate, and other measures. The most commonly used is the recordable incident rate, but this rate does not take into account the differences between fatalities, severe injuries, and minor injuries.

This study seeks to define a new measure to be used in place of the recordable incident rate that weighs different incidents according to their severity. These weighting factors are based

primarily upon average incident rates and their severity as measured by lost workdays. By taking data available from 2003-2008 of fatalities and recordable injuries in the United States, the severity of these injuries was normalized using a normal distribution, followed by their classification into four different categories with respective weighting factors. As fatalities are a permanent and almost immeasurable loss, these were placed as a single category, ranked in severity above all injuries.

This method resulted into the grouping of five categories of recordable cases namely, minor injury, moderate injury, severe injury, extreme injury, and fatality. The weighting factors for these five categories are 1.00, 1.78, 2.68, 4.96, and 6.20, respectively. In addition, every year, these weighting factors would be recalculated based upon the previous six years of data in order to keep the weighting factors relevant to current incident trends. By updating this data and announcing these weighting factors, OSHA could release an easy-to-follow incident rate data that accurately portrays the amount of recordable cases, while portraying the differing severity of these cases.

Overall, this study sought to find an improved way of measuring injuries and fatalities in order to create a more comprehensive statistical measure. Previously, the primary measure of injuries and illnesses in the workplace was the recordable incident rate. By measuring the severity of injuries and illnesses using lost workday data, the incident rate could be measured with weighting factors for difference injuries. This would allow a quick way to calculate the severity of the cases at a company by simply looking up what class each injury belonged to and using the appropriate weighting factor.

These weighting factors were calculated by taking data from 2003-2008 on lost workday rates for the 16 most common workplace injuries. By using the normal distribution to find the percentile that each injury belonged to, they were classified according to severity. In addition, fatalities were able to be included by the allocation of a weighting factor 1.25 times that of the greatest weighting factor. The five classes, ranging from minor injuries to fatalities, had weighting factors from 1.00 to 6.20 depending on the severity of the case. This combination of the incident rate and lost workday rate provides a clearer picture of the true impact of recordable cases at a company. Such a measure would allow OSHA, safety personnel, and interested individuals to get a better idea of the safety and hazards present a company or facility, allowing efficient and proper actions to be taken if necessary.

Literature Review

The nationwide practice of analyzing workplace injuries through the use of data began in late 1930's. The American Standard Method of Measuring and Recording Work Injury Experience (Z16.1 standard) was used as the method to define what constituted a workplace injury, and the BLS collected data nationwide pursuant to companies voluntarily supplying incident rates based on the Z16.1 standard. While this information was extremely important for a nationwide effort at gauging trends, there were several acknowledged biases in the collected data. Companies were not required to supply information; therefore, data was only representative of companies volunteering to supply information. Additionally, the Z16.1 did not specify many occupational illnesses as being recordable and injuries requiring medical treatment but involving less than one day away from work. These illnesses were also not recorded (Bureau of Labor Statistics, 2001).

With the passing of the OSHAct in 1970, OSHA carried out the requirement in Section 24 of the OSHAct through the provisions in 29 Code of Federal Regulation (CFR) Section (§) 1904. The purpose of 29 CFR § 1904 "is to require employers to record and report work-related fatalities, injuries and illnesses." The two aforementioned sources of variability were now reduced as the definition of injury broadened in scope to include occupational illnesses and most companies were now required to record these injuries and illnesses. Workplace incidents required to be recorded were now defined to be new, work-related injuries and illnesses resulting in death, medical treatment, loss of consciousness, restriction of work or motion, or transfer to another job; minor injuries resulting in first aid are not recordable.

Companies with more than ten employees or not exempt per §1904.2 were now required to record these injuries through the following (or equivalent) forms: OSHA 300 Log of Work-Related Injuries and Illnesses; OSHA300-A Summary of Work-Related Injuries and Illnesses; and OSHA301 Injury and Illness Incident Report. The information required per the OSHA300-A may be the foundation of the calculation of incident rates. Required information includes the total counts of recordable cases; cases with days away from work; cases with job transfer or restriction; total number of days away from work; days of job transfer or restriction; and total hours worked by all employees in the last year. These numbers are the variables used in formulating the incident rates because they constitute the numerator and denominator of an incident rate formula.

Overall data from all recordable cases, company counts of workers and work hours, and detailed data derived from incident reports, is required for all cases regarding days away from work. Injury and illness data from the mining and railroad industries is supplied to BLS by the Mine Safety and Health Administration and the Department of Transportation, respectively (Bureau of Labor Statistics 2002). All data is collected, analyzed to incorporate sampling error and inference techniques, and aggregated at the State and National level to produce overall incident rates and descriptive statistics of those incident rates and other reported data; data and analysis can be broken down to the individual state, cascading levels of industry, and overall national rates. Other data collection efforts that produce similar data analysis are conducted by OSHA and the Office of Personnel Management. Federal agency data is collected by OPM and reported to OSHA (Federal Injury and Illness, 2009). OSHA, through its OSHA Data Initiative (ODI), targets a specific subset of high-hazard private industries to derive incident rate data annually (Occupational Safety & Health Administration, 2005).

While companies may use these rates internally, OSHA also uses calculated incident rates as a discovery tool to evaluate company compliance to OSHA standards. Using data derived from their ODI survey, OSHA identifies companies with larger than average incident rates, both TRCR and DART. In 2010, OSHA sent letters to over 15,000 companies notifying them of high rates. The letters offer these companies assistance by highlighting the most frequently cited violations in their industry as well as information regarding OSHA's free consultation services (U.S. Department of Labor, 2010). Although there are no direct legal implications with these letters, OSHA also uses the ODI data to determine annual site-specific targeting plan. This plan involves OSHA performing unannounced safety inspections of companies that exhibit high incident rates; this may be a subpopulation of the population that received letters. Therefore, legal implications may arise during the site visit if violations were to be found. Conversely, through this plan, OSHA also randomly selects companies with unusually low incident rates as a sign of underreporting and possible violations (U.S. Department of Labor, 2008). Overall, it is clear that

incident rates are used as a tool by OSHA to determine site inspections, which may lead to legal ramifications for companies if violations were to be found.

Incident rates do not commonly equate to negative economic implications for a company; they do represent conditions within a company that have direct economic impact. Incident rates represent actual injuries which have direct and indirect economic impact for the company, industry, and their customers. Therefore, a high incident rate may represent a situation in which the company is investing a high amount of resources in addressing injuries and illnesses. Additionally, high incident rates may reflect higher worker compensation insurance rates. If incident rates are used as a tool for a summary of overall safety and health, then there may be direct economic implications for a company. For instance, contracts between two companies or a company and the government may require incident rates to be below a determined number. If incident rates were to exceed the expected value, then companies may lose the contract.

Experimental Design

In order to determine the relevant weighting factors for this study, the first step was to gather relevant data on the number of injury and fatality cases over the last several years. This data was obtained since lost workdays were to be used as the basis for the weighting factors; the average lost workdays for these injuries were also obtained. Using OSHA's statistics database and additional information from the United States Bureau of Labor Statistics, 16 categories of injuries, such as back pain, sprains, fractures, and amputations, were obtained from 2003 – 2008 on all industries in the nation (private and public).

The analysis of the data was performed by finding the mean and standard deviation of each sample population. Because fatalities are categorized on their own due to their severe and especially important nature, only the data for different injury types was analyzed. To ensure that no unusual events in a specific year resulted in an abnormally high or low amount of particular cases, any data points outside of two standard deviations from the mean were not used. 75% of the obtained data points where located within two standard deviations of the mean of the population. The mean of a sample was determined as shown in equation 1.

$$\mu = \frac{1}{N}\sum_{i=1}^{N} x_i, \quad \text{..... (1)}$$

Where x_i is each data point within population of size $\boldsymbol{N}$

The obtained mean was then used to calculate the standard deviation of a population (equation 2).

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \bar{x})^2}{N-1}} \quad \text{..... (2)}$$

Once the mean and standard deviation of each injury's lost workday rate were obtained, the mean of the entire population of all types of injuries and standard deviation were determined. This was used to find the percentile of each injury type, including the mean lost workdays within the sample of the 16 types of injury based on the normal distribution that was obtained from the probability density function (equation 3).

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-(x-\mu)^2}{2\sigma^2}} = \frac{1}{\sigma}\phi\left(\frac{x-\mu}{\sigma}\right). \quad \text{..... (3)}$$

The percentile of each injury's mean lost workday was obtained from the cumulative distribution function, which is the integral of the probability density function shown in equation 4.

$$\Phi(x) = \int_{-\infty}^{x} \phi(t)\,dt = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-t^2/2}\,dt. \quad \text{..... (4)}$$

Once the percentile of each injury's lost workday rate was calculated, the injuries were broken up into four categories, based on the quartile they fell into. The mean lost workday rate for each quartile was then calculated using equation 1. These values were then normalized by dividing each value by the lowest quartile's value, using equation 5.

$$\mu_{normalized} = \mu/\mu_{min} \quad \text{..... (5)}$$

The normalized means were used as the weighting factors for each category of injury. Although fatalities are very difficult to quantify due to their unique and serious nature, this category needed a weighting factor as well. In order to quantify its magnitude, the weighting factor for fatality incidents was set at 1.25 times the greatest weighting factor. It should be noted that this is an arbitrary value, since it takes into account their level of severity without using a weighting factor that would result is an overly large proportion of the new incident rate which will be composed of fatalities.

Results

Tables 1 – 3 show the results of data obtained on various injuries and incidents as well as their frequency of occurrence, including mean lost workdays, injury lost workdays, percentiles and weighting factors from 2003 – 2008.

Table 1. – Total Cases per Case, 2003-2008.

Injury/Incidents	Frequency of Occurrence (In Thousands)							Standard Deviation
	2003	2004	2005	2006	2007	2008	Mean	
Fatalities	55.75	57.64	57.34	58.4	56.57	52.14	56.31	223
Fractures	949.6	940.4	958.3	941.1	949.5	896.5	939.23	2194
Sprains, strains, tears	5639.1	5253.9	5035.3	4727.4	4483.8	4166.2	4884.28	53475
Amputations	81.5	81.6	84.5	79.9	73.2	62.3	77.17	820
Bruises	1188	1146.8	1077.7	1012.6	1013.4	936.5	1062.5	9366
Heat burns	196.1	185.1	171.5	174.4	174.9	156.3	176.38	1340
Back pain	374.7	379.3	356.5	353.3	371.3	371.4	367.75	1042
Soreness, pain, hurt	664.0	666.3	651.6	697.2	784.1	768.9	705.35	5732
Tendonitis	77.3	69.3	57.2	47.5	43.8	41	56.02	1468
Fatalities	55.75	57.64	57.34	58.4	56.57	51.24	56.16	257
Contact with equipment	3417.5	3351.6	3380.8	3354.6	3175.5	2918.8	3266.47	18976
Fall to lower level	826.7	798	793.1	742.8	773	675.1	768.12	5342
Fall on same level	1745.7	1670.1	1671.8	1517.5	1665.6	1576.8	1641.25	8092
Overexertion	3391.4	3166.7	2981.3	2849.1	2649.3	2509.6	2924.57	32663
Overexertion in lifting	1850.6	1734	1599.7	1509.9	1403.3	1299.9	1566.23	20532
Repetitive motion	574.2	487.1	437.9	383.1	367	309.2	426.42	9466
Transportation accidents	576.7	628.6	611.7	561.7	533.2	486.1	566.33	5215
Violent acts by person(s)	165.6	176.7	145.6	159.7	168.4	163.3	163.22	1036

Table 2. – Mean Lost Workdays, 2003-2008.

Year	2003	2004	2005	2006	2007	2008	Mean	Standard Deviation
Fractures	30	28	27	28	30	28	28.50	1.12
Sprains, strains, tears	8	8	8	8	8	9	8.17	0.37
Amputations	30	25	22	22	21	26	24.33	3.09
Bruises	4	4	4	4	4	4	4.00	0.00
Heat burns	5	5	5	5	5	6	5.17	0.37
Back pain	7	7	7	7	8	6	7.00	0.58
Soreness, pain, hurt, (non-back related)	10	8	6	7	8	9	8.00	1.29
Tendonitis	11	13	12	14	10	11	11.83	1.34
Contact with objects and equipment	5	5	5	5	5	5	5.00	0.00
Fall to lower level	15	14	13	14	15	15	14.33	0.75
Fall on same level	9	9	8	9	9	10	9.00	0.58
Overexertion	10	9	8	9	9	10	9.17	0.69
Overexertion in lifting	9	8	8	8	8	10	8.50	0.76
Repetitive motion	22	20	19	19	20	18	19.67	1.25
Transportation accidents	14	10	10	10	10	12	11.00	1.53
Assaults and violent acts by person(s)	5	6	5	5	5	6	5.33	0.47

Table 3. – Injury Lost Workdays Percentiles and Weighting Factors.

Injury	Percentile	Class	Weighting Factor	Normalized Factor
Fractures	0.99	A	24.17	4.96
Sprains, strains, tears	0.34	C	8.69	1.78
Amputations	0.97	A	24.17	4.96
Bruises	0.16	D	4.88	1.00
Heat burns	0.20	D	4.88	1.00
Back pain	0.28	C	8.69	1.78
Soreness, pain, hurt, except the back	0.33	C	8.69	1.78
Tendonitis	0.54	B	13.08	2.68
Contact with objects and equipment	0.19	D	4.88	1.00
Fall to lower level	0.67	B	13.08	2.68
Fall on same level	0.38	C	8.69	1.78
Overexertion	0.39	C	8.69	1.78
Overexertion in lifting	0.35	C	8.69	1.78
Repetitive motion	0.88	A	24.17	4.96
Transportation accidents	0.49	C	8.69	1.78
Assaults and violent acts by person(s)	0.21	D	4.88	1.00
Fatality	N/A	X	X	6.20

Based on the data analysis, the injuries were broken up into four categories and fatality was considered the fifth category. The least severe injuries were found to be bruises, heat burns, contact with objects and equipment, and assaults and violent acts by person(s), all with a weighting factor of 1.00. The most severe injuries were found to be fractures, amputations, and repetitive motion, all with a weighting factor of 4.96. It is important to note that some injuries may fall into multiple categories. For example, an individual could get into a transportation accident, a class C injury, but that same accident could result in fractured bones, a class A injury. In these cases, the more severe of the two classes would be used to classify the injury and it would not be recorded as two separate cases for each type of injury. Lastly, because class A injuries have a weighting factor of 4.96, fatalities would have a weighting factor of 1.25 times that, which is equal to 6.20.

Interestingly, when one thinks of the most severe injuries, it would be no surprise that fractures and amputations would be class A injuries. However, it is noteworthy that repetitive motion injuries are also class A. This is of important note and gets to the heart of how this new measure helps portray a more accurate picture of these cases in the workplace because if one were to see, for example, ten cases of repetitive motion injuries, but only one fracture, they may think that is not very serious. In fact, those are two of the most severe injuries, and seeing the weighted incident rate would reflect this fact.

In order to adequately achieve the expectation of the weighting factors, it would be necessary to update the weighting factors every 5 – 10 years. This would ensure that the weighting factors reflect current trends, as some other factors such as medical effectiveness may change that could reduce the severity of specific injuries. When these medical changes occur, the weighting factors would need to change with them in order to ensure that a modern and accurate portrayal of workplace injuries is presented. Keeping this system would be vital to its relevance and effectiveness in properly portraying the benefits of including weights in the incident rate decision-making process.

Conclusion

This research was able to provide an improved method of measuring injuries and fatalities in order to create a more comprehensive statistical measure. Previously, the primary measure of injuries and illnesses in the workplace was the recordable incident rate. By measuring the severity of injuries and illnesses using lost workday data, the incident rate could be measured with weighting factors for difference injuries. This would allow a quick way to calculate the severity of the cases at a company by simply looking up what class each injury belonged to and using the appropriate weighting factor.

These weighting factors were calculated by taking data from 2003-2008 on lost workday rates for the 16 most common workplace injuries. By using the normal distribution to find the percentile that each injury belonged to, they were classified according to severity. In addition, fatalities were able to be included by giving them a weighting factor 1.25 times that of the greatest weighting factor. The five classes, ranging from minor injuries to fatalities, had weighting factors from 1.00 to 6.20 depending on the severity of the case. This combination of the incident rate and lost workday rate provides a clearer picture of the true impact of recordable cases at a company. Such a measure would allow OSHA, safety personnel, and interested individuals to get a better idea of the safety and hazards present a company or facility, allowing efficient and proper actions to be taken if necessary.

Future Work

While this study takes into account the severity of the injury and illness discussed, it does have its limitations. It will be important to allocate actual weighting factor to fatalities. Since fatalities cannot be assigned a lost workday, using a lost workday basis to calculate the weighting factors (as done in this research) does not adequately reveal the value of the effect of a fatality. In the future, it will be important to find a way to quantify a fatality in comparison to other recordable cases would greatly help in a study such as this. One possible way to do such quantification would be to take into account worker's compensation awards. As these awards are measurable and comparable, they could allow a quantifiable way of calculating these weighting factors. Another drawback of this study is that weighting allocation takes into account the opinions of

courts, lawyers, and defendants, in addition to the defendants lost income. This may create a human variable that is arbitrary in some ways, especially in cases involving fatalities and the assignment of 1.25 times the maximum weighting factor.

A final thought on how to quantify the fatalities in this context would be to perform an analysis on the data of the average salary of an individual and average age of retirement at a corporation. By taking the average salary and multiplying it by the expected remaining time of an employee at a certain age, one could calculate an expected value of their remaining time at a corporation. The issue with this method would be that it would be heavily individualized to each company or even to each facility. Nevertheless, finding a way to quantify fatalities in an accurate and proper way is an important thing for future work in a study like this. In addition to the difficulty of quantifying fatality, some industries may tend to have different rates of recordable cases. For example, a dangerous job such as fire fighting may have a much higher rate of injury than a job in a typical office building. Finding specific data for every industry could be very time consuming. By creating computer programs with proper algorithms for analyzing data, such as done in this study, different weighted incident rates can be determined for every type of job or industry.

The applications of this study are much the same as the other incident rates used by OSHA and other safety and hazard studies. All of these rates aim to quantify injuries, illnesses, and fatalities in a way to help summarize how often or serious the cases of a specific industry or company are. Currently, the most commonly used rate is the recordable incident rate, but this rate does not differentiate between a fatality and a sprained leg or any other recordable case Overall, not only would it give OSHA and other record keeping bodies a better idea of what safety and hazards occur at a company, but it could be very useful to the company itself as well in order to improve its safety procedures in an effective and efficient way.

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