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A statistical study of occupational accidents in the manufacturing industry in Turkey

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ABSTRACT

One of the most important field of economy is manufacturing. The highest number of occupational accidents occurs in manufacturing. In Turkey, more than half of these accidents occur in this field (56% in 2012). This study aims to identify the contributory factors of such accidents and examine the relationship between Lost Work Days (LWD), Post-Accident State (PAS) and Type of Accidents (TA) using data mining, correspondence analysis and chi-square test. The analyses have shown the most frequently encountered TA is "pressing of the body or members between two objects" and its predictors are Sector, Size, and Age, Experience, Hours Day. This type of accident is most likely to occur in sector 25 (manufacture of fabricated metal product, except machinery and equipment), with a higher likelihood for the businesses with fewer than 500 employees and in the employees aged less than 40. As a result, the incapability of work is found to be as a period of 30–59 days. Consequently, it is recommended that higher premium ratios should be imposed to urge the businesses to take measures and supervision practices by the social security supervisors should be more frequent.

1. Introduction

Occupational accidents is one of the leading challenges most sectors encounter in economy. Most laborers are faced with numerous risks and the number of occupational accidents is higher than reported in developed and developing countries (Hämäläinen et al., 2006). 6300 people die every day as a result of occupational accidents or work-related diseases – more than 2.3 million deaths per year. Annually, 317 million accidents most of which bring about prolonged absences from work occur. (ILO, 2015). Turkey in particular ranks the third after El Salvador and Algeria in fatal accidents in the world and is at the top of the list of occupational accidents in Europe. The rate of the fatal occupational accidents is 20.5 employees per 100,000 population in Turkey, but it is two employees per 100,000 population in countries such as Norway, Sweden, and Denmark (ILO, 2014). According to the Ministry of Labor and Social Security, 172 daily occupational accidents occur in Turkey, with four deaths and six workers becoming incapable of work permanently (Ministry of Labor and Social Security, 2013). According to the Council of Workers' Health and Workplace Safety, 1270 workers lost their lives in the first eight months of 2014 due to occupational accidents, exceeding the 1235 deaths in 2013. In the last decade, 6428 workers have lost their lives due to occupational accidents. The number of the workers having lost their lives at work between 2000 and 2014 is over 15000 (Occupational Health and Safety Council, 2014).

The major reasons why the occupational accidents are so common in Turkey are the lack of effective policies, that of strict supervision, the 2% premium set without considering the number of the occupational accidents per company per year and with no reference to the category and severity of the hazard (Altunkaynak and Ozturk, 2016). However, countries such as Germany, France, Belgium, and Italy use a premium system that incorporates rewards and sanctions in the determination of the rate of premiums for occupational injuries and diseases (Eurogip, 2004). Moreover, the formal statistics concerning unregistered employment rate, the number of occupational accidents and diseases are not reliable and thought to reflect the less of what the actual situation is (Karadeniz, 2012).

The cost of occupational accidents is huge. At the country level, the economic burden of poor occupational safety and health practices is estimated at 4 percent of global Gross Domestic Product each year (ILO, 2015). At the organization level, there emerges a significant negative influence of occupational accidents on financial performance of the company (Argiles-Bosch et al., 2014). Further, as

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an outcome concerning organizational culture, workplace accidents cause a perceived lack of influence and a distrust of management (Barling et al., 2003). These observations point to the growing importance of workplace health and safety.

On the other hand, it is quite remarkable to note that 50% of the occupational accidents can easily be prevented, 48% are preventable with a systematic effort, but only 2% of the accidents cannot be prevented (Disbudak, 2013). It is necessary to analyze occupational accidents by type and causality to produce solutions for prevention. This also has a positive effect on the selection and application of the preventive measures.

A perusal of the literature demonstrates that occupational accidents happen more frequently in sectors such as mining, industry, construction and agriculture and more fatal accidents take place in these sectors. Studies conducted in different occupational sectors include mining (Maiti et al., 2009; Sanmiquel et al., 2015), industry (Nenonen, 2011; Carrillo-Castrillo et al., 2012; Hedlund, 2013), construction (Haslam et al., 2005; Hola and Szostak, 2014; Irumba, 2014) and agriculture (Kumar and Dewangan, 2009; Robert et al., 2015).

Among these sectors, the manufacturing industry is one of the most dangerous branches in light of the frequency of occupational accidents (Nenonen, 2011). In 2007, the number of accidents causing absence more than 3 days at manufacturing companies in EU-15 countries and Norway added up to 942,000 and 667 fatal accidents were recorded in the manufacturing industry (Eurostat, 2009). In Turkey, more than half of the occupational accidents occur in manufacturing industry. However, there are very few studies investigating the accidents in manufacturing industry as a whole. Limited number of current studies focus on the accidents in sub-sectors such as metal and furniture industries in Turkey (İlhan et al., 2013; Akalp et al., 2015). However, there are some studies reporting occupational accidents in the manufacturing sector. As these studies deal with only a small part of the manufacturing sector, they cannot be used to compare the sectors by the number of accidents.

The manufacturing sector is heterogeneous, considering the subsectors involved. The types of accidents with lost work days may be variable by sector. However, the social security system does not take this into account and imposes the same premium ratio (2%) for all the sectors and companies. As a result, firms feel not obliged to take measures to prevent occupational accidents.

Identifying the type of accidents and the outcomes of these accidents could help to find out which sector experiences relatively more occupational accidents. However, the type of accidents may not only be determined by sector but also by factors such as employees and the workplace conditions. As a result, if these factors can be identified, the sources of the accidents could be ascertained. For example, the accidents may be caused by inexperience on the part of the employees, inadequate training, and poor working conditions. Consequently, the current study has the following objectives:

To identify

1. the variables affecting the type of accidents in the manufacturing sector
2. the most frequent type of accident
3. the outcomes of the most frequent type of accident
4. the antecedents of the most frequent type of accident
5. the variable levels that maximize the degree of probability of the type of accidents

2. Material and methodology

Data mining techniques have been used in the present study to meet the objectives of the study, even though the aims of data mining, and some of its methods, overlap with those of classical statistics. A great number of statistical models are available for the statistician to explain relationships in a data set or to make predictions. Among these are cluster analysis, discriminant analysis and nonparametric regression that can be used in data mining problems. As a result, data mining seems, to the statistician, to be only one of the branches of statistics (Hosking et al., 1997). However, the data mining problems and the methods employed have their own characteristics. First, data sets can be far larger than it is usually used in statistics. Second, differences of emphasis exist in the approach to modeling: compared with statistics, data mining pays less attention to the large-sample asymptotic properties of its inferences and more to the general philosophy of “learning”, including consideration of the complexity of models and of the computations that they need. Some modeling techniques, such as rule-based methods (decision tree, association rules etc.), are difficult to fit into the classical statistical framework, and others, such as neural networks, have an extensive methodology and terminology that has developed largely independently of input from statisticians. On the other hand, analysis of simulated data indicates that, in general, methods based on data mining are more sensitive in detecting associations among many categorical variables than other statistics methods (Sanmiquel et al., 2015).

Powerful statistical tools, such as variable selection, decision trees, Bayesian networks, association rules among other data mining techniques are available for data analysis. In addition, some of the classical statistical techniques, such as Chi-square, Z test, and Correspondence Analysis can be effectively used in examining uncomplicated relationships (e.g., examining the relationship between two variables) (Hosking et al., 1997).

This study has used data mining techniques and classical statistical techniques in combination for different purposes. First, using *variable selection*, we identified which variables had significant effects on the type of accident. Thanks to variable selection, it is possible to obtain better classification results using fewer variables. At this stage, there are different evaluators and search methods suggested in the literature. However, being heuristic, these methods may yield conflicting results. Thus, it is necessary to try more than one method simultaneously for the results to be reliable in order to obtain similar results (Guyon and Elisseeff, 2003). This is very important in terms of consistency of the results. Next, we used *decision trees* to determine in which classes of the selected variables for classification emerged what type of accidents. Decision trees are functional if the response variable is categorical (e.g., type of accident in the current study) (Agrawal et al., 1993). There are a number of algorithms like *OneR, KNN, ID3, J48, NaiveBayes* in building decision trees when the response variables are categorical. Each of these algorithms should be tried and the algorithm with the highest accuracy for classification should be selected. In addition, we used *Bayesian networks* to calculate probability for the nodes of decision trees. *Bayesian networks* are used in association rules to determine the rules of highest probability as well. As for *classical statistics*, we used *chi-square* to test the relationship between the two categorical variables (e.g., *Type of Accidents* and *Lost Work Days*). In addition, when the relationship is found to be significant, a more detailed explanation is necessary. Therefore, when we found a significant relationship between variables, we used *Z-test* to compare the proportions between classes. Finally, we preferred *correspondence analysis*, whereby the relationship between classes can be illustrated in a more visual way, to graphically show the relationship between classes.

2.1. Study population

There are 39,327 instances of occupational accidents recorded in the Turkish manufacturing sector in 2012. This data is concerned