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Estimating the possibility of workday loss accidents in road construction

Authors:

Assist.Prof. **Atiye Bilim**, PhD. CE
Konya Technical University, Konya, Türkiye
Department of Occupational Health and Safety Programme
abilim@ktun.edu.tr
Corresponding author

Prof. **Osman Nuri Çelik**, PhD. CE
Konya Technical University, Konya, Türkiye
Department of Civil Engineering
oncelik@ktun.edu.tr

Research Paper

Atiye Bilim, Osman Nuri Çelik

Estimating the possibility of workday loss accidents in road construction

Worksite hazards and occupational accidents in road construction pose significant risks to worker safety and productivity, necessitating a comprehensive understanding of the factors contributing to workday loss. This study aimed to determine the probability of workday loss owing to occupational accidents among road workers based on individual and occupational characteristics. Univariate statistical analysis, cross-tabulation, and binary logistic regression were used for data analysis. A binary logistic regression analysis was conducted using data from 5,519 occupational accidents during road construction between 2013 and 2016. The independent variables included the workers' age, sex, marital status, occupational health and safety (OHS) training, experience, education, occupation, accident season, accident location, and material causing the accident. An equation was derived to estimate the probability of workday loss given a worker's experience, OHS education, season, location, and the material involved. In conclusion, this study demonstrated the applicability of logistic regression analysis in determining the probability of workday loss owing to occupational accidents. This approach can be used across different sectors, reducing workday loss accidents and associated costs while promoting worker health and sustainable production policies.

Key words:

occupational accident, logistic regression, road construction, occupational safety

Prethodno priopćenje

Atiye Bilim, Osman Nuri Çelik

Procjena vjerojatnosti gubitka radnih dana zbog nesreća na radu u cestogradnji

Opasnosti na radnom mjestu i nesreće na radu u cestogradnji predstavljaju značajne rizike za sigurnost i produktivnost radnika te zahtijevaju sveobuhvatno razumijevanje uzroka koji utječu na gubitak radnih dana. Cilj ovog istraživanja je odrediti vjerojatnost gubitka radnih dana zbog nesreća na radu koje se događaju radnicima u cestogradnji na temelju individualnih karakteristika i zaštite na radu. U analizi podataka primjenjene su statističke analize jedne varijable, unakrsne analize tablica i binarna logistička regresija. Binarna logistička regresijska analiza provedena je na temelju podatka o 5519 nesreća na radu u cestogradnji između 2013. i 2016. godine. Nezavisne varijable odnose se na dob radnika, spol, bračni status, obuku iz područja zaštite na radu (engl. *occupational health and safety* - OHS), iskustvo, obrazovanje, zanimanje, godišnje doba, lokaciju nesreće i uzrok koji je prouzročio nesreću. Pomoću predloženog modela je vjerojatnost gubitka radnog dana na temelju iskustva radnika, obrazovanja u području zaštite na radu, godišnjeg doba, lokacije i materijala. Istraživanje pokazuje primjenjivost analize logaritamska regresije u određivanju vjerojatnosti gubitka radnog dana zbog nesreća na radu. Takav pristup može se koristiti u različitim sektorima, jer doprinosi smanjenju nesreća na radu i povezanih troškova zbog gubitka radnih dana, a promovira zdravlje i sigurnost radnika i politike održive gradnje.

Ključne riječi:

nesreća na radu, logistička regresija, cestogradnja, zaštita na radu

1. Introduction

Worldwide, occupational injury rates in the construction sector are higher than those in other major industries [1, 2]. Data from several industrialised countries show that the death of construction workers from accidents at work is three to four times more likely than other workers [3]. The construction industry is a complicated sector in terms of working conditions; it is dynamic and dangerous because of the temporary nature of construction workplaces and workforce [4-8]. Construction sites are often described as unsafe and dangerous places [9]. Each construction project is different, and each project type has its own characteristics, working performance methods, materials, and construction techniques [10]. Situations such as variability in construction activities and equipment can cause uncontrollable human errors [11]. Therefore, occupational accident rates in this industry are high.

Damage to human, business, and economic resources from occupational accidents in the construction industry has become a serious problem. Occupational safety is a problem requiring attention at all construction sites. However, the same types of hazards and accidents are not expected to occur at all construction sites. In general, there is an infinite variety of hazards and risks that cannot be completely identified in the construction industry, and special precautions must be taken and implemented according to the existing construction type to eliminate these risks [12].

Most studies state that road construction projects have higher risks than other construction projects because they both spread to a wider geographical area and face threats from underground conditions [13-15]. The injury rate in the construction industry is still unacceptable [16]. It is categorised as a high-risk work site because of its significant number of fatalities [17].

Roadwork construction involves a complex and hazardous environment with many dynamic resources, including staff, equipment, and materials [18]. Some researchers have pointed out the inadequacy of the work done in urban construction activities that will bring together the worker and user in the same denominator and make the construction site dangerous for the public as well as the worker [19, 20]. However, some researchers have argued that safety practices within the industry leave much to be desired, exposing workers to unnecessary occupational risks [21-24]. From the standpoint of labour protection, road construction is considered a comparatively dangerous industry because it includes practically all the risk factors of the working environment. Highway and street construction workers are at risk of fatal and severe nonfatal injuries when working near passing motorists, construction vehicles, and equipment [25-28]. If sufficient attention is not paid to safety measures, this can harm both workers and the nation.

Every worker in the construction area should be examined together with workers in that area to minimise occupational accidents and correctly identify hazards. Scientific studies are needed that show worker profiles according to different types of construction (such as buildings, roads, dams, and tunnels) and the number of workers in the construction industry [29, 30]. Statistical data are important for accident prevention and serve as a starting point for safety studies [16]. Analysis of accident records provides a valuable way to identify accident patterns in professional populations. Occupational accidents are complex events in which many factors affect causality. Their prevention is only possible by analysing past events and accurately interpreting statistical results [31-33]. Data on occupational accidents should be analysed carefully. It is important to prioritise occupational safety policies and get valuable tips [34]. If the causes of occupational accidents are known, the priority of possible precautions can be determined. In addition, if the laws have flaws, they will contribute to closing these defects.

Occupational accidents and the associated workday losses are of significant concern in various industries. To mitigate this problem, scholars have increasingly turned to logistic regression analysis to identify the factors contributing to accidents and develop effective preventative strategies. This method allows for the investigation of the relationships between various independent variables and the dependent variable, thereby providing insights into the dynamics of occupational health and safety (OHS).

Several studies have implemented logistic regression analyses to explore the factors that lead to occupational accidents. For instance, Chau et al. [35] employed logistic regression to study occupational accidents in the Hong Kong construction industry and identified a significant relationship between factors such as work experience, type of work, and accident occurrence. Similarly, Kines et al. [36] used logistic regression analysis to investigate the influence of individual and work-related factors on the risk of falls in the Danish elderly care sector. Their findings highlighted the importance of ergonomic interventions and safety training for reducing the risk of falls among employees.

Moreover, in their study on the mining industry, Sanmiquel et al. [37] applied a logistic regression analysis to identify the factors contributing to fatal accidents, revealing a significant association between the type of accident, the material agent involved, and the probability of fatality. A study by Dong [38] in the US construction sector also used logistic regression to explore the relationship between various worker characteristics and the likelihood of occupational injuries, highlighting the elevated risk among younger and less experienced workers.

In a different context, Nuwayhid et al. [39] used logistic regression to investigate the association between occupational injuries and various health conditions among industrial workers in Lebanon, emphasizing the role of poor health status as a significant risk factor for occupational injuries. Onder [40] applied a logistic regression analysis method to nonfatal occupational injuries from 1996 to 2009 in an opencast coal mine for the Western Lignite Corporation (WLC) of Turkish Coal Enterprises and found that the job group with the highest probability of exposure to accidents with more than three lost workdays for nonfatal injuries was maintenance personnel and workers.

In summary, these studies demonstrate the versatility and effectiveness of logistic regression as a tool for understanding and preventing occupational accidents in various industrial sectors. However, further research using this method in the context of road construction, which is known for its high rate of occupational accidents and associated workday losses, is required.

When occupational accidents in the construction industry are analysed in Turkey, road construction is ranked first in terms of the accident frequency rate [41]. In this study, univariate frequency, cross-tabulation, and binary logistic regression analyses were used to analyse occupational accidents during road construction. The hazards and risk factors were identified for each industry.

This study primarily aimed to determine whether it is possible to determine the probability of workday loss according to the individual and occupational characteristics of road workers experiencing an occupational accident. Binary logistic regression analysis was applied to determine whether worker and worksite characteristics affected workday loss owing to an occupational accident. A model that estimates the probability of workday loss is derived by assuming that the worker had an accident.

2. Material and method

In Turkey, workers are obliged to complete the "Work Accident and Occupational Disease Notification Form" and notify the Social Security Institution (SSI). In this form, the personal information of the workers, the working environment, and various information related to the work are included. In this study, a dataset was created by arranging information obtained from the SSI.

This study was divided into three parts. In the first part of this study, 14630 injured occupational accidents that occurred during road construction between 2013 and 2016 were considered. The construction sector in Turkey has been subdivided into specific branches, and the statistics have been maintained since 2013. Consequently, we plan to examine road construction over four years, starting in 2013. Raw data were transformed into a usable form for statistical analysis. The new dataset is divided into 11 independent variables and several subcategories. Workday loss was the dependent variable. In the second part of the study, the frequency tables of the variables determined for 14630 injured occupational accidents were examined. To make the study result meaningful in the data related to occupational injuries, erroneous and incomplete data were removed from the dataset, and the number of occupational injury accidents was reduced to 5519. A cross-tabulation analysis was performed to examine the relationship between each independent and dependent variable.

In the third step, a model that could determine the possibility of workday loss in occupational accidents during road construction was derived using binary logistic regression analysis.

2.1. Univariate frequency and cross-tabulation analysis

A total of 5519 injured occupational accident data points were prepared for the analysis. This dataset was divided into two categories: occupational accidents and casualty information. Univariate frequency analyses were performed for these categories. In the category related to occupational accidents, the materials causing the accident, the place where the accident occurred, and the season in which the accident occurred were included (Table 1). In the category related to casualties, there

Table 1. Distribution of occupational accident data

Dependent variable	Independent variables	Categories of independent variables	Frequency	Percent [%]
Workday loss	Material caused the accident	Construction parts	2056	37.3
		Land and other vehicles	1414	25.6
		Hand tools	830	15.0
		Machinery and equipment	1014	18.4
		Harmful substances	126	2.3
		Physical facts and natural factors	79	1.4
	Accident place	Industrial site, workshop, factory	223	4.0
		Construction site	4136	74.9
		Office, social activity areas	30	0.6
		Public areas-road-transportation vehicles	552	10.0
		Out of the construction site	578	10.5
	Accident season	Winter	1145	20.7
		Spring	1275	23.1
		Summer	1489	27.0
		Autumn	1610	29.2

Table 2. Distribution of data regarding casualties

Dependent variable	Independent variables	Categories of independent variables	Frequency	Percent [%]
Gubitak radnih dana	Experience	< 1 year	133	2.4
		1 to 10 year	2004	36.3
		10 to 20 year	1538	27.9
		20 years and above	1844	33.4
	OHS training	No	227	4.1
		Yes	5292	95.9
	Education status	Illiterate	16	0.3
		Primary education	4566	82.7
		High school and above	937	17.0
	Age	< 18	3	0.1
		18 to 30	1833	33.2
		30 to 40	1546	28.0
		> 40	2137	38.7
	Gender	Female	10	0.2
		Male	5509	99.8
	Vocational training	No	1012	18.3
		Yes	4507	81.7
	Occupation	Managers	5	0.1
		Professionals	53	1.0
		Technicians, assistant professionals	181	3.3
		Service, sales and office staff	68	1.2
		Craftsmen	2025	36.7
		Plant and machine operators	1626	29.5
		Employees who do not require qualification	1561	28.3
	Marital status	Single	1528	27.7
		Divorced	208	3.8
		Widow	8	0.1
		Married	3775	68.4

is information about the worker's age, gender, marital status, occupational health and safety (OHS), training vocational training, experience, educational status, and occupation (Table 2). Independent variables related to occupational accidents, casualties, and their subcategories were determined (Tables 1 and 2).

Workday loss was selected as the dependent variable for the model. The independent variables that may affect workday loss are workers' OHS and vocational training, gender, educational status, age, marital status, occupation, experience, season in which the accident occurred, place where the accident occurred, and the material that caused the accident.

Cross-tabulation analysis was conducted in the Statistical Package for the Social Sciences (SPSS) to examine the relationship between workday loss and the independent variables. After the cross-tabulation and the frequency distribution were included in the cells, the second stage involved questioning the relationships between variables. Pearson's X^2 test is one of the methods used to determine the potency of this relationship. This test compares the observed values with the expected values if no relationship exists between the two variables [42].

Pearson's X^2 test hypothesises that the variables in the rows and columns can be independent or dependent. The null hypothesis formulated within the scope of this study is as follows:

- H_0: There is no relationship between the independent and dependent variables (workday loss).
- H_1: There is a relationship between the independent and dependent variables (workday loss).

The p-value based on Pearson's X^2 value (which expresses the importance of X^2) should also be calculated by considering

Table 3. Cross tabulation summary table

Independent variables	Pearson's X^2 (df), p	
OHS training	$X^2(1) = 5.905$	p = 0.015
Experience	$X^2(3) = 27.635$	p = 0.000
Accident season	$X^2(3) = 18.312$	p = 0.000
Accident place	$X^2(5) = 59.161$	p = 0.000
Material caused the accident	$X^2(5) = 79.818$	p = 0.000

the degrees of freedom. The p-value is the probability used to determine the degree to which the observed value deviates from the expected value by chance. If the P-value was less than 0.05, the Ho hypothesis was rejected, and the relationship between the variables was accepted.

The relationship between workday loss, defined as the dependent variable, and the 11 independent variables was analysed using cross-tabulation analysis. Table 3 shows that the independent variables have a significant relationship with the dependent variable through cross-tabulation. The cross-tabulation results for the other independent variables are not presented because they are not significantly related to the dependent variable.

As seen in Table 3, the five independent variables are statistically related to the dependent variable. Thus, the number of independent variables used in the future logistic regression models was reduced.

2.2. Logistic regression analysis

The relationship between the dependent and independent variables is not linear; it can be exponential or polynomial. Logistic regression assumes a logit relationship between dependent and independent variables so that it can produce nonlinear models.

The model created in the logistic regression analysis was nonlinear. Therefore, the probability of the occurrence of Y is predicted using independent variables. The logistic regression model is generally expressed in eqn (1).

$$Pi = (Y \mid X) = e^{(\beta_0 + \beta_1 X_1 + \ldots + \beta_n X_n)} / (1 + e^{(\beta_0 + \beta_1 X_1 + \ldots + \beta_n X_n)}) \tag{1}$$

where:

Pi - the probability of observing the event under consideration
β_0 - constant term
$\beta_{1\ldots}\ \beta_n$ - regression coefficients of independent variables
$X_{1\ldots}\ X_n$ - independent variables
n - number of independent variables
e - Euler's number, 2.71.

The logistic regression method aims to establish a model that describes the relationship between dependent and independent variables, with the least variable in the best fit [43].

3. Results

After cross-tabulation analysis, five independent variables with a significant relationship with the dependent variable were determined (Table 3). Studies have been conducted using logistic regression analyses of occupational accidents in different sectors [44-48]. In this study, logistic regression analysis was preferred as the best technique to explain the cause–effect relationship between the variables in question, since the dependent variable had a qualitative and binary categorical structure, and the independent variables had a categorical structure. In addition, binary logistic regression analysis was performed to determine the combined effects of variables. The accident data used in the application study were divided into categories to make them suitable for the logistic regression analysis (Table 4).

In the analysis performed, the variable specified as "Y" in Table 4 was considered the dependent variable, whereas the variables X_{OHS}, $X_{experience}$, X_{season}, X_{place}, $X_{material}$ were considered independent variables. The main hypothesis of the study was that occupational health and safety education and the experience of the worker, material, season, and workplace significantly affect workday loss. A list of variables in the model developed to estimate workday loss is presented in Table 5. In practice, the effects of the independent variables X_{OHS}, $X_{experience}$, X_{season}, X_{place}, $X_{material}$ on the probability of workday loss were determined using binary logistic regression analysis.

A simple binary logistic regression analysis performed between the independent variables and the workday loss variable, which is the dependent variable in the model, is presented in Table 5. Descriptive statistics of the variables are presented in Table 5:

- Column B presents the coefficients corresponding to the independent variables.
- The standard errors of the coefficients are listed in column SE.
- The Wald column contains Wald statistical values.
- The p column presents the significance levels of the statistics.
- The df column enumerates the degrees of freedom.
- The column labelled Exp(B) shows the estimated values of the likelihood ratio.

Binary logistic regression analysis was performed using SPSS, and the last subcategories of the independent variables were selected as the reference category.

Table 4. Variables used in the model

Variables	Explanation of variables	Explanation of subcategories
Y (dependent variable)	Workday loss	Accidents with no workday loss Accidents with workday loss
X_{ohs}	Worker's occupational health and safety training	No Yes
$X_{experience}$	Experience of worker	Experience 1 (less than 1 year) Experience 2 (1–10 years) Experience 3 (10–20 years) Experience 4 (20 years and above)
X_{season}	Accident season	Season 1 (Winter) Season 2 (Spring) Season 3 (Summer) Season 4 (Autumn)
X_{place}	Accident place	Place 1 (Industrial site, workshop, factory) Place 2 (Construction site) Place 3 (Office, social activity areas) Place 4 (Public areas-road-transportation vehicles) Place 5 (Out of the construction site:In air-above water- high pressure-underground)
$X_{material}$	Material caused the accident	Material 1 (Construction parts) Material 2 (Land and other vehicles) Material 3 (Hand tools) Material 4 (Machinery and equipment) Material 5 (Harmful substances:chemical, radioactive, biological) Material 6 (Physical facts and natural factors)

Table 5. Statistics of the variables in the logistic regression model

Variables in equation									
		B	SE	Wald	df	Sig.	Exp (B)	95 % C.I. for Exp(B)	
								Lower	Upper
Step 1[a]	Experience 4 *			25.642	3	0.000			
	Experience 1	-0.860	0.185	21.686	1	0.000	0.423	0.295	0.608
	Experience 2	-0.179	0.072	6.152	1	0.013	0.836	0.725	0.963
	Experience 3	-0.041	0.078	0.280	1	0.597	0.960	0.824	1.118
	No OHS training	-0.453	0.145	9.762	1	0.002	0.636	0.479	0.845
	Season 4 *			15.017	3	0.002			
	Season 1	0.218	0.087	6.285	1	0.012	1.243	1.049	1.474
	Season 2	0.145	0.083	3.023	1	0.082	1.156	0.982	1.361
	Season 3	-0.084	0.078	1.162	1	0.281	0.919	0.789	1.071
	Place 5 *			63.042	4	0.000			
	Place 1	1.317	0.214	37.975	1	0.000	3.731	2.454	5.671
	Place 2	0.407	0.095	18.363	1	0.000	1.502	1.247	1.809
	Place 3	-0.067	0.389	0.030	1	0.863	0.935	0.436	2.004
	Place 4	0.871	0.140	38.758	1	0.000	2.389	1.816	3.142
	Material 6 *			87.164	5	0.000			
	Material 1	-0.578	0.287	4.066	1	0.044	0.561	0.320	0.984
	Material 2	-0.987	0.288	11.751	1	0.001	0.373	0.212	0.655
	Material 3	-0.273	0.294	.865	1	0.352	0.761	0.428	1.353
	Material 4	-0.247	0.292	.714	1	0.398	0.781	0.441	1.385
	Material 5	-0.624	0.342	3.322	1	0.068	0.536	0.274	1.048
	Constant	1.019	0.301	11.445	1	0.001	2.769		

-2LL = 6634.554 (log likelihood - LL) **Hosmer&Lemeshow Chi-Square Test = $X^2(8) = 11.915$, $p = 0.155$**

Step 1[a] - Variable(s) entered on step 1: Experience, OHS training, Accident season, Accident place, Material caused the accident.

* Reference category

Table 6. Importance of variables in the model (model fit if significant variables are removed)

Model if term removed					
Variable		Model Log Likelihood	Change in -2 Log Likelihood	df	Significant of the change
Step 1	Experience	-3329.927	25.300	3	0.000
	OHS training	-3322.005	9.456	1	0.002
	Season	-3324.821	15.089	3	0.002
	Place	-3351.403	68.251	4	0.000
	Material	-3361.577	88.600	5	0.000

In the experience category, the "20 years and more" experience group was selected as the reference category. The probability of having an accident with workday loss was 2.36 times less for workers with less than 1 year of experience (1/0.423), 1,196 times less (1/0.836) for those with 1–10 years of experience, and 1.041 times less for those with 10–20 years of experience (1/0.960) compared to workers with 20 years and more professional experience. Therefore, workers with more than 20 years of experience have the highest risk of occupational accidents involving workday losses. The group least likely to have an accident with workday loss had less than one year of experience. Workers with less experience are expected to experience more accidents. However, the contrary result can be attributed to the fact that the proportion of employees with less than one year of experience in the dataset is quite small (2.4 %).

Autumn was selected as the reference category. The probability of having an accident with workday loss is 1.243 times more in winter accidents and 1.156 times more in accidents in spring, compared to the workplace accidents in autumn, while the probability of workday loss in summer accidents is 1.088 times less (1/0.919).

Those who have received OHS training have been selected as the reference category in the OHS training category. Compared with those who have received occupational health and safety training, the probability of an accident with workday loss is 1.572 times lower for workers who have not received occupational health and safety training (1/0.636).

In the place category, "Out of the construction site" has been selected as the reference category. Compared to those outside the construction site, the probability of having an accident with workday loss is 3.731 times higher for those who work in industrial sites, factories, and workshops; 1.502 times higher in construction sites; and 1.069 times higher in public areas-road-transportation vehicles (1/0.935), while it is 2.389 times lower in office and social activity areas.

The "Physical facts and natural factors" accident material groups were selected as reference categories in the material category. The probability of having an accident with workday loss according to physical facts and natural factors, which are among the subcategories that cause the accident, is 1.782 times (1/0.561) less in accident material 1 0.2.680 (1/0.373) times in accident material 2, 1.314 (1/0.761) times in material 3, 1.280 (1/0.781) times in material 4, and 1.865 (1/0.536) times in material 5 times.

The independent variables that increased the probability of workday loss were season 1 (winter) and season 2 (spring), and place 1 (industrial site, factory, workshop), place 2 (construction site), and place 4 (public area-road-transportation vehicles).

Logistic regression relies on the log-likelihood function to compare the observed and predicted values. The log probability parameter was calculated by testing the goodness-of-fit of the model. To estimate how well the model fits the data, −2log probability (−2LL) is typically used, as multiplying the log probability value by −2 yields an approximate χ^2 distribution. A decrease in the −2LL value indicates an improvement in the model fit. Table 6 summarises the importance of the variables. This can be understood by examining the log-probability values of how each of the variables included in the model affects the model when removed. The accident material variable is currently the most important factor in this model.

One of the methods used to evaluate the model fit in logistic regression is the Hosmer–Lemeshow test. The following assumptions were made for this test:

- H_0: model is suitable for the data.
- H_1: The model is not suitable for the data.

If the test result is not significant and the sig value is greater than 0.05, the H_0 hypothesis is accepted. Thus, it can be concluded that the model data are significant.

According to the Hosmer–Lemeshow test results in Table 5, the significance value was found to be 0.155 ($p > 0.05$). If this value is not significant, it indicates that the model has an acceptable fit and that the model and data fit are sufficient.

The predictive power of the model was 69.5 %. The equation created using the coefficients (B-values) of the model obtained from the binary logistic regression analysis presented in Table 5 is given in Equation (2).

$$\begin{aligned} Y = {} & 1.019 - 0.860\,X_{experience1} - 0.179\,X_{experience2} - 0.041\,X_{experience3} \\ & - 0.453\,X_{ohs} + 0.218\,X_{season1} + 0.145\,X_{season2} - 0.084\,X_{season3} \\ & + 1.317\,X_{place1} + 0.407\,X_{place2} - 0.067\,X_{place3} + 0.871\,X_{place4} \\ & - 0.578\,X_{material1} - 0.987\,X_{material2} - 0.273\,X_{material3} \\ & - 0.247\,X_{material4} - 0.624\,X_{material5} \end{aligned} \tag{2}$$

Remark: Equation (2) can be explained as follows:

Model case: A worker with 21 years of experience and OHS training suffered an accident owing to machinery and equipment at a construction site in autumn, which resulted in workday loss. When this occurs in the resulting model,

$$Y = 1.019 - 0\,(\text{experience4}) - 0\,(\text{training}) + 0\,(\text{season}) + 0.407\,(\text{worksite}) - 0.247\,(\text{material})$$

$$Y = 1.179$$

$$Pi = E(Y \mid X) = e^{(\beta_0+\beta_1 X_1+\ldots+\beta_k X_k)} / (1+e^{(\beta_0+\beta_1 X_1+\ldots+\beta_k X_k)}) = e^{1,179}/(1+e^{1,179}) = 0,76$$

Because the value found was greater than 0.50, this worker has a high probability of having an accident with workday loss, according to the model. This implies that a worker with these qualifications has a 76 % probability of experiencing an occupational accident with workday loss.

If the value was less than 0.50, the worker had a low probability of workday loss accidents. Therefore, if the worker information in the equation is known, the possibility of a workday loss accident can be determined. Serious accidents can be reduced by identifying workers with a high probability and taking proactive measures specific to them.

4. Discussion

Accident data of workers who had an occupational accident during the 2013–2016 road constructions were analysed by performing univariate frequency analysis, cross-tabulation analysis, and binary logistic regression analysis.

According to the results of the univariate frequency analysis: It was concluded that structural parts, followed by vehicles, are the most important material that causes occupational accidents. Material drop is a significant risk factor for all construction sites in the construction industry. A similar result was obtained when accidents at road construction sites were evaluated. It was observed that accidents mainly occurred in the construction area, and the least number occurred in the office. Such a result is likely to occur because construction sites are in the main work class and are very dangerous. Most accidents occurred during autumn.

When evaluated in terms of experience, workers with 1–10 years of experience were exposed to the highest number of accidents. Second, the workers must have at least 20 years of experience. Therefore, the category of experience alone does not make sense. A significant proportion (82.7 %) of workers who suffered accidents in this sector were primary school graduates. Therefore, it was concluded that the educational level of most of those who experienced an accident was low. From a professional perspective, craftsmen, the actual labourers in the construction business, are exposed to most accidents. When the age category was evaluated, those aged 40 years or older were exposed to the highest number of accidents. With increasing age, a decrease in reflex ability increases the risk of accidents. A significant majority of workers exposed to accidents receive occupational and vocational training. It was determined that 68.4 % of the workers who had accidents in the sector were married. Married workers are more concerned about losing their jobs because of their sense of responsibility towards their families than are unmarried workers. Significantly, as the number of married workers' dependents increases, workers' anxiety increases, which harms their business life. Working in intense and heavy conditions to support families increases the risk of occupational accidents. In addition, situations such as uneasiness and conflict in the family cause a decrease in the motivation and concentration of workers. It may be possible to reduce accidents by paying attention to employing married and older workers in less-risky areas of the sector.

Based on the results of the cross-tabulation analysis, five independent variables were statistically significant. These variables were worker experience, OHS training, accident season, material causing the accident, and accident location. When looking at the results of the logistic regression analysis, it should be noted that the research also used data on accidents at work that occurred between 2013 and 2016. Nonfatal accidents resulting in the loss of days in the industry can be reduced or prevented with appropriate analyses and precautions. Because logistic regression models are flexible and suitable for categorically grouped data, this study proved that they can be used in many fields, including road construction.

Workers with over 20 years of experience were at the highest risk of accidents involving workday losses. Workday loss in accidents is not directly proportional to experience. Having sufficient professional experience has been revealed to be insufficient to prevent occupational accidents.

The probability of having an accident with workday loss is 1.243 times more in winter accidents and 1.156 times more in accidents in spring, compared to the workplace accidents in autumn, while the probability of workday loss in summer accidents is 1.088 times less. Therefore, seasonal spring and winter are important in terms of the possibility of accidents with workday losses.

Workers who did not receive OHS training were 1.572 times less likely to experience accidents with workday loss than those who received OHS training. These results are expected to be meaningful. Training for occupational accidents is expected to prevent, reduce, or decrease the severity of accidents. However, the following conclusion can be reached: the issue of the adequacy of OHS training has come to an agenda. If the hazards and risks of the work are adequately explained to the worker in the OHS training, it may be possible to reduce the severity of accidents because workers who are aware of the hazards and risks will be more careful. Therefore, civil engineers should be the experts who provide OHS training.

Compared to those who work out of the construction site, the probability of having an accident with workday loss is 3.731 times higher for those working in the industrial, factory, or workshop, 1.552 times higher in construction site, 1.069 times higher in public area-road-transportation vehicles, while 2.389 times less in office and social activities.

According to the physical and natural factors that cause accidents, the probability of accidents with workday loss is 1.782 times lower for construction parts, 2.680 times lower for land and other vehicles, 1.314 times lower for hand tools, 1.280 times lower for machinery and equipment, and 1.865 times lower for harmful substances.

Using Equation (2), presented in chapter 3, obtained from the binary logistic regression analysis, if a worker's experience, OHS education status, season, place, and material are known, the probability of this accident resulting in a workday loss can be calculated. OHS precautions specific to workers with a high probability of losing their workdays can be implemented.

5. Conclusion

This research was conducted by examining 5519 case reports of road construction accidents in Turkey over a four-year period, with the express consent of the Social Security Institution. Logistic regression analysis was utilised to address questions such as the influence of individuals' demographic characteristics on occupational accidents. This analysis is particularly effective for investigations related to human behaviour. Therefore, in this study, logistic regression analysis was chosen to determine the reasons for occupational accidents in road construction.

By applying logistic regression analysis, this study derived an equation that can be used to estimate the probability of workday loss for workers given their experience, OHS training status, season, work environment, and accident-causing materials. This equation can be utilised by organisations to implement targeted OHS precautions and proactive solutions to reduce workday accidents.

Overall, this study highlights the importance of understanding the factors that contribute to workday loss accidents to protect worker health, reduce direct and indirect costs, and promote sustainable production policies. The data used in this study were derived from work-related accidents in Turkey. Therefore, the results may differ from those obtained in other countries. However, as some parameters are similar, concepts such as comments, model development, and methods can also be used in other countries.

By conducting similar analyses across different sectors and countries, organisations can take essential steps to minimise the impact of occupational accidents on both workers and overall productivity. Furthermore, the findings of this study allow for potential comparisons. Examining demographic characteristics through such studies can serve as valuable criteria for employee recruitment. This is owing to the occupational safety principle of aligning work with individuals, wherein identifying a suitable worker profile for a specific job emerges as a contributing factor in reducing work-related accidents.

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