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A Dynamic Risk Analysis Model Based on Workplace Ergonomics and Demographic-Cognitive Characteristics of Workers

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Abstract: Background: This study aimed to examine the effect of perception, attention, and sleep levels on the number of occupational accidents and near-misses in the mining and metal sectors. Methods: The data were collected from 53 employees in the mining (n = 30) and metal (n = 23) sectors in 2021 from a mining and metal company. The study collected the following data from the sample: demographic information forms, previous accident and previous near-miss histories, Pittsburgh Sleep Quality (PSQI) scale, pulse, sleep levels, and attention tests. Results: Having an education at primary school and below (B = 0.235; $p < 0.05$), and having an education at the high school level (B = 0.710; $p < 0.01$), being single (B = −0.291; $p < 0.01$), time working in the department (B = 0.027; $p < 0.05$), time working in the company (B = −0.034; $p < 0.05$), and the number of near-misses (B = 0.354; $p < 0.01$), had a significant impact on accidents. Having an education in primary school or below (B = −1.532; $p < 0.01$), not having had an accident (B = −3.654; $p < 0.01$), age (B = 0.074; $p < 0.01$), correct score (B = 0.014; $p < 0.01$), incorrect time (B = 0.228; $p < 0.01$) and unanswered score averages (B = −0.029; $p < 0.01$) had a significant impact on near-misses. Conclusion: Education, the working year, and working time had significant effects on workplace accidents.

Keywords: preventative; cognitive; perception; risk analysis; mining; metal

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1. Introduction

Occupational accidents are a crucial problem that affects both the working levels of individuals and the use of human capital in working environments. They reduce the quality of people's lives [1,2]. Although many studies have been conducted on occupational accidents from the past to the present, occupational accidents continue in a way that can give undesirably severe results, especially in labor-intensive sectors such as mining and metal [3].

According to the literature, occupational accidents occur from successive causes. The next one does not take place unless one of these occurs, and there is no accident or injury until the sequence is completed. An unplanned and unknown potentially damaging event should also occur [4,5]. In this case, an accident must be present for injury or damage to occur, that is, to occur with all elements of the accident [6,7].

According to Article 3 of the Occupational Health and Safety Law No. 6331, which is an occupational safety regulation that the Turkish Government adopted on 20 June 2020, an occupational accident is an event that occurs in the workplace or, due to the performance of the work, causes death or disrupts mental or physical integrity. However, according to Article 13 of Law No. 5510 of the Ministry of Labour and Social Security of the Republic of Turkiye, the concept of the occupational accident is the accident that the insured person suffers while in the workplace if he/she works independently on his/her account [8].

Conceptually, accident prevention activities mean controlling the performance of the workforce, the performance of tools, devices, and machines, and the physical environment.

The purpose of the controlled study included both the prevention and correction of unsafe situations and events. Preventing accidents is vital for any industrial organization [9,10]. If the accident is not prevented properly, it will cause injury, death, and/or material losses and adversely affect the business [7].

While there are diverging views on the occurrence of occupational accidents based on different studies on the weight relationships of the causes of occupational accidents, it would be correct to accept that 80% of occupational accidents are human-originated, 18% are physical and mechanical, and 2% are environmental and unexpected events. This generalization reveals that preventive measures can be taken in approximately 98% of occupational accidents [11].

Occupational accidents affect not only workers but also employers, workers' families, society, and the country and constitute considerable costs. They also create a lot of costs, such as absenteeism, loss of income, job loss, and loss of time. According to the International Labor Organization, the economic burden of poor occupational health and safety practices is approximately 4% of the world's gross domestic product every year [12–14]. For these reasons, it is crucial to spread the occupational safety culture and ensure occupational safety management to prevent occupational accidents in the workplace, reduce their effects, and create healthier and safer working environments [8].

Mining and metal industries are among the production areas where workplace accidents are most common [15–17]. The fact that the metal and mining sectors are interconnected in terms of raw materials and production also leads to companies operating in both sectors. Therefore, these companies have more accident factors than other companies in terms of occupational health and safety.

Although some studies have been conducted on the effect of perception, attention, and sleep levels on occupational accidents, there are not enough studies on dynamic risk modeling and the examination of these variables together in both the mining and metal sectors. For this reason, this study aims to examine the effect of perception, attention, and sleep levels on the number of occupational accidents and near-misses in the mining and metal sectors [18–20].

2. Method

The research was designed in a descriptive screening model, and the digital measurement process took biometric measurements through the survey method as the data collection method.

2.1. Population Sample

The research population consists of mining and metal sector employees, and the sample consists of 53 employees from the mining (n = 30) and metal (n = 23) sectors working in 2021 in a mining and metal company which is one of the companies having two working places in two cities: in Kastamonu and Ankara at Turkiye.

There has not been enough work done on a company operating in two different and related sectors. Therefore, a power analysis was conducted for sample size calculation. Based on Silva et al. [21], the effect size was calculated from Gpower 3.1.9.2 as 0.4444444, and the minimum sample size was calculated as 35 with a 1.3069516 critical T value.

In Turkiye and in many regions of the world, the mining and metal sector are close to each other, and the same company could operate both in the metal sector with different firms. In fact, in this study, the aim was to reveal the effect of the sector by examining the same company operating in two different sectors. Concentrating on only one of the sectors that the company operates in would not fully express the effects of job safety risk factors for that company.

There were no accidents or near-misses in the places where the study was carried out during the research process. Findings about accidents and near-misses were obtained based on the past experiences of the employees participating in the research.

The collection of research data was done by the researcher himself. After obtaining the necessary permissions, the research data were collected from the employees at regular intervals and transferred to the computer by using the cluster sampling method and the whole count sampling method together by creating a data collection chart.

2.2. Data Collection Tools

The data collection tools were the demographic information form, accident and near-miss histories, the Pittsburgh Sleep Quality (PSQI) scale, pulse, sleep duration and quality, and perception tests for cognition.

The parameters such as pulse, sleep, REM, and active sleep were collected from the employees by constant observation through a measurement tool worn by the employee. While the measurement values were taken, all measurements were made and recorded by the researcher in specific areas.

The Pittsburgh Sleep Quality (PSQI) scale is a validated and reliable scale measuring sleep quality with 19 items developed by Buysse et al. [22] and validated in Turkish form by Agargun et al. [23]. PSQI analyzes seven components: subjective sleep quality, sleep onset latency, sleep duration, sleep efficiency, sleep disturbance, use of hypnotic medication, and daytime dysfunction. It has been revealed that the sleep quality level taken from the scale is related to the deterioration in psychomotor and neuropsychological functions. Both clinical and psychological findings reveal that the scale adequately represents sleep quality in psychometric terms [23]. High scores indicate low sleep quality. An accident indicates any occupational accident history related to the current job, whereas a near-miss indicates an accident that could have happened soon but did not happen.

2.3. Research Hypothesis

The study had the following alternative hypotheses:

H1. *Risk factors for the working and workplace where production is processed environment in the mining and metal sectors, and accident rates have a statistically significant effect on dynamic risk analysis.*

H2. *Risk factors for the working and working environment in the mining and metal sectors and near-miss rates have a statistically significant effect on dynamic risk analysis.*

2.4. Statistical Method

Fischer's exact test was used in the difference analysis of nominal and ordinal data in the study. The Kolmogorov–Smirnov test checked whether the data fit a normal distribution. The Mann–Whitney U test determined the difference between the two groups. Spearman's rho correlation and generalized linear model (GLM) analysis was performed in relational screening analysis. All analyses were in SPSS 17.0 for Windows, with a 95% confidence interval and $p = 0.05$ as the threshold for statistical significance.

Since dependent variables, near-misses, and accident parameters were nonparametric categorical parameters, Spearman's rho correlation analysis was used for a univariate relationship, and generalized linear model (GLM) analysis was used for a multivariate relationship in order to evaluate the effects of factors together. The behavior of dependent variables was dichotomous, or dummy variables and the statistical strategy was selected as a generalized logit model [24].

3. Results

The distribution of some demographic and professional characteristics of the participants according to their companies is given in Table 1.

Age, years of employment in the sector, years of employment in the company, and mean mild sleep were statistically significantly higher in the metal sector company ($p < 0.05$). Pulse, sleep, REM, and sleep parameters were measured by researchers using diagnostic tools. The year working in the department is higher in the company in the mining sector

($p < 0.05$). The education variable between the two companies also differs statistically significantly ($p < 0.05$).

Table 1. Distribution of some demographic and professional characteristics of the participants according to their companies.

Company	Mine (N = 30)	Metal (N = 23)	Total (N = 53)	Test Value	*p*-Value
Age (Mean ± SD)	31.37 ± 4.85	38.61 ± 7.48	34.51 ± 7.11	69,457.500	**0.000 *[a]**
Education, n (%)					
Primary school or below	1 (3.3)	9 (39.1)	10 (18.9)		
High school	6 (20.0)	4 (17.4)	10 (18.9)	12.099	**0.002 [c]**
University and above	23 (76.7)	10 (43.5)	33 (62.3)		
Sector year, mean ± SD	6.02 ± 4.57	**14.61 ± 7.39**	9.75 ± 7.32	47,407.500	**0.000 *[a]**
Department year, mean ± SD	**5.18 ± 4.01**	5.17 ± 4.40	5.18 ± 4.18	132,961.500	**0.000 *[a]**
Company year, mean ± SD	3.48 ± 2.18	**5.17 ± 4.40**	4.22 ± 0.3	141,120.000	**0.035 [a]**
Marital status, n (%)					
Single	21 (70.0)	9 (39.1)	30 (56.6)	(50.51)	**0.024 [b]**
Married	9 (30.0)	14 (60.9)	23 (43.4)		
Previous accident, n (%)					
No	25 (83.3)	20 (87.0)	45 (84.9)	0.133	0.514 [b]
Yes	5 (16.7)	3 (13.0)	8 (15.1)		
Number of previous accident experiences	0.27 ± 0.77	0.57 ± 2.06	0.40 ± 1.48	148,176.000	0.230 [a]
Previous near-miss, n (%)					
No	23 (76.7)	16 (69.6)	39 (73.6)	0.338	0.393 [b]
Yes	7 (23.3)	7 (30.4)	14 (26.4)		
Previous near-misses, mean ± SD	0.77 ± 1.57	1.83 ± 3.32	1.23 ± 2.54	145,089.000	0.087 [a]
Instantaneous pulse, mean ± SD	89.90 ± 17.90	91.19 ± 18.27	90.46 ± 18.07	145,821.000	0.234 [a]
Daily pulse, mean ± SD	89.34 ± 17.08	91.07 ± 17.75	90.09 ± 17.39	143,452.000	0.102 [a]
Deep sleep, mean ± SD	1.54 ± 0.87	1.47 ± 0.86	1.51 ± 0.87	145,277.500	0.196 [a]
REM, mean ± SD	0.92 ± 0.54	0.92 ± 0.51	0.92 ± 0.53	151,962.500	0.973 [a]
Mild sleep, mean ± SD	2.74 ± 1.48	**3.01 ± 1.61**	2.86 ± 1.54	138,274.500	**0.009 [a]**
Active time, mean ± SD	0.75 ± 0.44	0.74 ± 0.43	0.74 ± 0.44	151,206.000	0.860 [a]

[a] Mann–Whitney U Test, [b] Fischer's Exact Test, [c] Chi-square similarity ratio, SD: Standard Deviation, * bold values are statistically significant.

The mean values of the perception, attention and PSQI parameters of the participants and the results of the difference analysis are in Table 2.

The average of correct questions, time, and scores, incorrect time, unanswered time, and the total score is higher in the company in the metal sector, while the average of unanswered questions and scores and PSQI is statistically significantly higher in the company in the mining sector ($p < 0.05$).

Spearman's rho correlation analysis results for checking the relationship between the number of accidents and demographic characteristics, job characteristics, and research parameters are in Table 3.

Table 2. The mean values of the perception, attention, and PSQI parameters of the participants and the results of the difference analysis.

Mean ± SD	Mining (N = 30)	Metal (N= 23)	Total (N = 53)	Value of the Test	*p*-Value [a]
Correct answer	10.75 ± 2.92	12.52 ± 3.04	11.52 ± 3.10	104,253.000	0.000
Correct time	2.88 ± 0.66	2.99 ± 0.42	2.93 ± 0.57	127,825.000	0.000
Correct score	51.21 ± 13.63	59.63 ± 14.47	54.86 ± 14.60	103,747.000	0.000
Incorrect answer	5.79 ± 3.33	5.78 ± 2.48	5.79 ± 2.99	149,581.500	0.628
Incorrect time	2.93 ± 1.21	3.41 ± 0.68	3.14 ± 1.04	108,080.500	0.000
Incorrect score	27.59 ± 15.87	27.52 ± 11.83	27.56 ± 14.25	149,581.500	0.628
Unanswered question	4.46 ± 3.32	2.69 ± 2.07	3.69 ± 2.98	105,635.000	0.000
Unanswered time	4.54 ± 1.45	4.91 ± 0.68	4.70 ± 1.19	140,973.000	0.000
Unanswered score	21.22 ± 15.82	12.80 ± 9.88	17.56 ± 14.19	105,957.500	0.000
Total score	0.49 ± 0.10	0.54 ± 0.05	0.51 ± 0.08	103,534.500	0.000
ST	9.13 ± 2.95	9.18 ± 1.87	9.16 ± 2.54	150,892.000	0.812
PSQI	13.78 ± 2.18	13.18 ± 2.86	13.52 ± 2.51	130,301.500	0.000

[a] Mann–Whitney U Test, SD: Standard Deviation.

Table 3. Spearman's rho correlation analysis results for the relationship between the number of accidents and demographic characteristics, job characteristics, and research parameters.

Number of Previous Accidents	r	*p*
Education level	0.060 *	0.045
Age	−0.017	0.572
Sector years	−0.052	0.084
Department years	0.139 **	0.000
Company years	0.109 **	0.000
Marital status	0.280 **	0.000
Previous near-miss	0.477 **	0.000
Number of previous near-miss incidents	0.600 **	0.000
Instantaneous pulse	−0.018	0.540
Daily pulse	0.036	0.233
Deep sleep	−0.020	0.507
REM	−0.019	0.527
Mild sleep	−0.009	0.773
Active time	−0.046	0.122
Company	−0.036	0.230
Measurement	0.000	10.000
Correct answers	0.001	0.963
Correct time	−0.054	0.071
Correct score	0.002	0.940
Incorrect answers	−0.078 **	0.009
Incorrect time	−0.009	0.766
Incorrect score	−0.078 **	0.009
Unanswered question	0.037	0.220
Unanswered time	0.077	0.011
Unanswered score	0.037	0.212
Total score	0.004	0.896
ST	0.038	0.211
PSQI	−0.036	0.225

* $p < 0.05$; ** $p < 0.01$.

According to the results of Spearman's rho correlation analysis, a statistically significant and positive relationship was present between the number of accidents and the

following parameters: education level (r = 0.060; $p < 0.05$), years working in the department (r = 0.139; $p < 0.01$), years working in the company (r = 0.109; $p < 0.01$), being married (r = 0.280; $p < 0.01$), having a near-miss (r = 0.477; $p < 0.01$), the number of near-misses (r = 0.600; $p < 0.01$), and the time spent on unanswered questions in the attention test (r = 0.077; $p < 0.01$). Again, a statistically significant and negative relationship was present between the number of accidents and the number of incorrect questions (r = −0.078; $p < 0.01$) and the incorrect score (r = −0.078; $p < 0.01$).

The results of the logit model (generalized linear model) analysis conducted to examine the effect of the parameters with significant correlation with the number of previous accidents on the number of previous near-misses are in Table 4.

Table 4. The results of the logit model (generalized linear model) analysis conducted to examine the effect of the parameters with a significant correlation with the number of previous accidents on the number of accidents at the multivariate level.

Parameter Name	B	Std. Error	95% Wald Confidence Interval		Hypothesis Tests	
			Minimum	Maximum	Wald x^2	*p*
(Intercept)	−0.042	0.1201	−0.277	0.193	0.122	0.727
[Education = primary school and below]	0.235	0.0938	0.051	0.419	6.272	0.012
[Education = high school]	0.710	0.0935	0.527	0.893	57.632	0.000
[Education = university]	0	-	-	-	-	-
Marital status: single	−0.291	0.0734	−0.435	−0.147	15.730	0.000
Marital status: married	0	-	-	-	-	-
Department years	0.027	0.0115	0.004	0.049	5.389	0.020
Company years	−0.034	0.0139	−0.062	−0.007	6.141	0.013
Number of near-miss incidents	0.354	0.0140	0.326	0.381	636.794	0.000
Incorrect score	-5.769×10^{-5}	0.0024	−0.005	0.005	0.001	0.981
Scale	1.226	−0.0520	1.129	1.333		

Log-likelihood: −1692.844; Akaike Information Criterion (AIC): 3403.688.

The logit model results showed that the following conditions were significantly effective on the number of accidents: having an education at primary school and below (B = 0.235; $p < 0.05$), having an education at high school level (B = 0.710; $p < 0.01$), being single (B = −0.291; $p < 0.01$), time working in the department (B = 0.027; $p < 0.05$), time working in the company (B = −0.034; $p < 0.05$), and the number of near-misses (B = 0.354; $p < 0.01$). While being single and increasing the number of working years in the company has a decreasing effect on the number of accidents, graduating from primary school and below and high school, increasing the number of years working in the department and increasing the number of near-misses increase the number of accidents. These results show that high school graduates are more effective in the field of work and cause fewer accidents; the number of accidents increases as the years working in the department increases, and the number of accidents decreases as the time working in the company increases.

Spearman's rho correlation analysis results for the relationship between the number of previous near-misses and demographic characteristics, professional characteristics, and research parameters are given in Table 5.

Table 5. Spearman's rho correlation analysis results for the relationship between the number of previous near-misses and demographic characteristics, professional characteristics, and research parameters.

Number of Previous Near-Misses	r	*p*
Education level	0.174 **	0.000
Age	−0.070 *	0.020
Sector years	0.050	0.094
Department years	−0.059	0.050
Company years	−0.025	0.403
Marital status	0.186 **	0.000
Previous accident	0.587 **	0.000
Instantaneous pulse	−0.004	0.897
Daily pulse	0.017	0.561
Deep sleep	0.015	0.624
REM	−0.001	0.980
Mild sleep	0.015	0.627
Active time	−0.040	0.187
Company	0.051	0.087
Measurement	0.000	1.000
Correct question.	0.131 **	0.000
Correct time	−0.073 *	0.014
Correct score	0.132	0.000
Incorrect question	−0.033	0.274
Incorrect time	0.113 **	0.000
Incorrect score	−0.033	0.274
Unanswered question	−0.123 **	0.000
Unanswered time	0.022	0.464
Unanswered Score	−0.122 **	0.000
Total Score	0.050	0.093
Week	0.000	1.000
ST	0.047	0.116
PSQI	0.047	0.113

* $p < 0.05$; ** $p < 0.01$.

According to Table 5, a statistically significant and positive relationship was present between the number of near-misses and the following conditions: being male (r = 0.078; $p < 0.01$), education (r = 0.174; $p < 0.01$), being married (r = 0.186; $p < 0.01$), having had an accident before (r = 0.587; $p < 0.01$), the number of correct questions (r = 0.131; $p < 0.01$), the correct number score (r = 0.132; $p < 0.01$), and the incorrect time (r = −0.113; $p < 0.01$). Again, a statistically significant and negative relationship was present between the number of near-misses and the following parameters: age (r = −0.070; $p < 0.05$), correct time (r = −0.073; $p < 0.05$), number of unanswered questions (r = −0.123; $p < 0.01$), and unanswered score (r = −0.122; $p < 0.01$).

The results of the logit model (generalized linear model) analysis conducted to examine the effect of the parameters with significant correlation with the number of near-misses on the number of accidents are in Table 6.

The following parameters have a statistically significant effect on the number of near-misses: having an education in primary school or below (B = −1.532; $p < 0.01$), not having had an accident (B = −3.654; $p < 0.01$), age (B = 0.074; $p < 0.01$), correct score (B = 0.014; $p < 0.01$), incorrect time (B = 0.228; $p < 0.01$), and unanswered score means (B = −0.029; $p < 0.01$). When the beta coefficients are examined, being a woman, having an education in primary school and below, not having an accident, being single, and having a high mean score reduce the number of near-misses.

Table 6. The results of the logit model (generalized linear model) analysis to examine the effect of the parameters with significant correlation with the number of previous near-misses on the number of previous accidents at the multivariate level.

Parameters	B	Std. Error	95% Wald Confidence Interval		Hypothesis Tests	
			Minimum	Maximum	Wald x^2	*p*
Intercept	1.199	0.5098	0.200	2.199	5.536	0.019
[Education = primary school and below]	−1.533	0.1692	−1.864	−1.201	82.000	0.000
[Education = high school]	−0.062	0.1607	−0.377	0.254	0.146	0.702
[Education = university and above]	0 [a]	-	-	-	-	-
[Accident = no accident]	−3.654	0.1758	−3.999	−3.310	431.951	0.000
[Accident = accident]	0 [a]	-	-	-	-	-
[Marital status = single]	−0.134	0.1310	−0.391	0.123	1.048	0.306
[Marital status = married]	0 [a]	-	-	-	-	-
Age	0.074	0.0092	0.056	0.092	63.629	0.000
Correct score	0.014	0.0047	0.005	0.023	8.529	0.003
Incorrect time	0.228	0.0610	0.109	0.348	14.016	0.000
Unanswered score	−0.029	0.0052	−0.039	−0.019	31.088	0.000
Scale	3.754 [b]	0.1591	3.455	4.079		

[a] Reference category, [b] Likelihood estimation.

4. Discussion

In this study, the extent to which the accident and near-accident cases of the employees in the mining and metal sectors are suitable for dynamic risk modeling methods and the effects of these parameters were analyzed with a single and multivariate method approach.

Studies on occupational health and safety from the past to the present report that the effect of demographic characteristics on occupational accidents varies according to the department, sector, job status, and company structure [25–27]. In these studies, although the mining and metal sectors are not sufficiently compared together, both sectors have been subject to research and examination because of their labor-intensive structure [11,28–30]. According to the results of this study, the following parameters were significantly statistically higher in the metal sector: the average age, years of work in the sector, years of work in the company, and mild sleep ($p < 0.05$). The number of working years in the department is higher in the mining sector ($p < 0.05$). Sex and education level variables between the two companies in two different sectors also significantly differ statistically ($p < 0.05$).

Studies in the mining and metal sectors in the literature reveal that demographic characteristics in the dimension of univariate analysis are statistically significantly related to accidents in both sectors [31–34]. In this study, a statistically significant and positive relationship was present between the number of accidents and the following demographic characteristics: education (r = 0.060; $p < 0.05$), years working in the department (r = 0.139), years working in the company (r = 0.109), being married (r = 0.280), having a near-miss (r = 0.477), the number of near-misses (r = 0.600), and the time spent on the unanswered questions in the attention test (r = 0.077). A statistically significant and negative relationship was present between the number of accidents and the number of incorrect questions (r = −0.078), and the incorrect score (r = −0.078). Correlation coefficients indicate that the most effective parameters are the number of near-misses and near-misses, followed by being married.

Multivariate analysis methods give more effective results in modeling and explaining the real situation than univariate analysis [35]. The results of the logit model in this study showed that the following parameters have statistically significant effects on the number of accidents: having an education at primary school and below, having an education

at the high school level, being single, time working in the department, time working in the company, and the number of near-misses. There are fewer studies conducted on near-misses than on accident cases. Additionally, the number of studies evaluating the mining and metal industries together and discussing the accident rates together with the near-misses is quite low. A statistically significant and positive relationship was present between the number of near-misses and the following characteristics: being male (r = 0.078), education (r = 0.174), being married (r = 0.186), having had an accident before (r = 0.587), the number of correct questions (r = 0.131), the correct number score (r = 0.132), and the incorrect time (r = −0.113). A statistically significant and negative relationship was present between the number of near-misses and the following characteristics: age (r = −0.070), correct time (r = −0.073), number of unanswered questions (r = −0.123), and unanswered score (r = −0.122). According to the correlation coefficients, having an accident has the highest impact, followed by being married, education, the number and score of corrects, and unanswered and incorrect numbers.

According to the results of the multivariate analysis, the following characteristics have a statistically significant effect on near-misses: having an education in primary school and below, not having had an accident, age, mean correct score, mean incorrect time, and mean unanswered score. This finding shows that the effect of the tests performed is significant in multivariate analyses. Therefore, unlike accident statistics, attention test results in near-miss statistics gain more meaning.

In the selection phase of the employees, definitions and limits, such as recruitment criteria, education level, and experience, are sometimes not enough to prevent accidents from occurring. In addition, the creation of a culture of occupational safety and the social life and health of employees directly affects occupational safety. Therefore, in order to increase the safety of employees, it is very important to observe them and to detect situations where they are not suitable for work conditions. In this way, it is important to allow them to focus on their day-to-day work and avoid dangerous behavior.

The mining and metal sectors are critical and high-risk sectors due to both the working environment and the heavy workload. The training, warnings, and necessary precautions are sometimes insufficient. For this reason, the use of developing technological opportunities is an important proactive approach to preventing accidents. In this way, the employee's suitability for daily work can be measured, and situations in which he is not even aware of himself can be determined.

Limitations, Benefits and Future Directions

The conducted research has twofold benefits: (1) İn two related sectors (metal and mining) operated by one company, occupational health and safety studies are conducted. (2) The research gives detailed information on risk factors that are important health and safety problems in these sectors.

Occupational burnout in accidents at work is an important limitation of the study. Since occupation takes an important time duration in daily life and having an accident in the workplace causes a decrease in the performance of workers, it also causes burnout, and this result may reflect results. Further research on the effects of occupational burnout will help to increase health and safety measurements.

Allocating longer time for data collection will reduce errors and increase consistency. The study can be improved further by collecting more diverse data via utilizing Internet of Things (IoT) devices and by comparing these data through accurate assessments. In addition, adding other sectors with other high accident rates and conducting them with larger participants will enable more sensitive and large-scale assessments to be made. This will allow seeing overlooked points. Utilizing artificial intelligence (AI) may help to make faster proactive decisions and reduce the occupational safety risk factor, even before near-misses. In this way, important results will be obtained for the detection of occupational accidents before they occur.

5. Conclusions

According to the results of the research, high school graduates are more skillful in preventing accidents in the workplace and cause fewer accidents, and the number of accidents increases as the years working in the department increase. On the other hand, it shows that as the time working in the company increases, accidents decrease. This situation needs to be examined in terms of whether the positive relationship between the increase in time working in the mining and metal sectors and the number of accidents is related to occupational burnout and fatigue or whether the existence of more working years means the possibility of more accidents. Therefore, work can be developed in this area with multicentered and larger samples. In this respect, the study constitutes a reference for further studies.

The following characteristics reduce the number of near-misses: being a woman, having an education in primary school and below, not having an accident, being single, and having a high mean score. These results show that the effect of attention and employees' perception is more crucial in the near-miss part of the accident. In addition, the relationship between accidents and near-misses reveals that if near-miss cases are not prevented, they are more likely to turn into accidents.

As a result, when the accidents and near-miss cases in the mining and metal sectors are considered in terms of dynamic risk modeling, it is seen that the effect of the variables related to the working environment and the employee is more critical in the cases with near-misses. This finding shows that occupational accidents in the mining and metal sectors can be prevented at the near-miss stage, and attention test results can be used effectively.

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