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OCCUPATIONAL ACCIDENTS IN THE SLOVAK FOREST SECTOR

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НЕСЧАСТНЫЕ СЛУЧАИ НА ПРОИЗВОДСТВЕ В ЛЕСНОМ ХОЗЯЙСТВЕ СЛОВАКИИ

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Abstract. The paper analyzes occupational accidents in selected forestry entities of the Slovak republic for the period 2000 – 2018. The aim of the article is to analyze the impact of chosen factors on the occurrence of occupational accidents in the group of forest workers. The basis for the analysis was the day and the hour when the occupational accident occurred, the information on harmed persons - gender, job, age, injured body part, the information about the factors affecting injuries. Data were evaluated graphically and the correlation between selected qualitative characteristics was determined by the method of contingency tables. The most risky work phase is logging. In the case of self-employed, the risk of fatal work-related accidents is higher than that of employees ($\alpha = 0,05$). For self-employed, the risk of injury due to the use of hazardous procedures is higher than that of employees ($\alpha = 0,05$).

Key words: occupational accidents; forestry; safety at work; logging process; work risk

Аннотация. В статье анализируются несчастные случаи на производстве в отдельных лесхозах Словацкой Республики за период 2000–2018 гг. Целью статьи является анализ влияния выбранных факторов на возникновение несчастных случаев на производстве в группе лесных рабочих. Основой для анализа послужили день и час возникновения несчастного случая на производстве, информация о пострадавших – пол, работа, возраст, травмированная часть тела, информация о факторах, влияющих на травмы. Данные оценивались графически, и корреляция между выбранными качественными характеристиками определялась методом таблиц сопряженности. Самым рискованным этапом работы является заготовка леса. В случае самозанятых риск несчастных случаев на производстве со смертельным исходом выше, чем у работников ($\alpha = 0,05$). Для самозанятых риск получения травм из-за использования опасных процедур выше, чем у работников ($\alpha = 0,05$).

Ключевые слова: несчастные случаи на производстве; лесное хозяйство; безопасность на работе; процесс регистрации; риск работы

Introduction. One of the main indicators of occupational safety and health is the risk of accidents at work. The main aim of international organizations dealing with health and safety at work is to reduce occupational accidents. The basic principles of the risk prevention include their identification and evaluation. Therefore, it is necessary to analyze the development of accidents at work, circumstances of their occurrence, basic characteristics of victims and other factors influencing the risk of the accidents at work.

In Turkey, a case study was developed to identify the factors responsible for fatalities in the logging process (Melenez, 2015). Personnel (32 %) and organizational factors (22 %) were confirmed as the most important factors. In Poland, a survey was conducted (Pecyna et al., 2019) on the causes of accidents in forestry. Respondents were presented with 16 common causes of accidents at work and they were asked to identify those that occur in their workplace. Respondents most often referred to human factors such as insufficient use of protective measures (63,7 %), underestimation of risk (63 %), persistence or entry into the hazardous area during logging (56,3 %). Common sources of accidents in Austrian forestry are the loss of machinery control, transport or handling equipment, hand tools and an object or animal, followed by slipping, and falling, falling and collapse of material (Kogler, Quendler, Boxberger, 2016). The most dangerous phases of the harvesting process in Italy are logging and wood handling with a 31 % share of work-related accidents out of the total number of accidents occurred in the harvesting process (Laschi et al., 2016). 25 out of 32 deaths of swedish forest workers between 1998 and 2002 were self-employed (Edgar, 2004). According to Thelin (2002), the most fatal accidents among the self-employed occurred when working with chainsaws.

The aim of the article is to analyze the impact of the chosen factors on the occurrence of work accidents in the group of forest workers in Slovakia.

Material and methods. The database was created from the data on work accidents in Slovak forestry. The following data on these criterions from the database were used: the kind of injury, the injured body parts and the cause of injury (Criterion were used according to the Ministry of labour, social affairs and family regulation nr. 500/2006 which imposes the model record of registered injury). Examined injuries were registered during the following phases and activities of the timber harvesting and transportation process: phase of wood felling and yarding, work process at forest depot, wood transport phase, work process at conversion depot and lower landing, repair and maintenance activity and control activity of technical and economic workers. Data was processed with Microsoft Excel.

Contigency table. The method of contingency table was used to analyze the relationship between quality characters (Table 1).

Table 1 – Example of contigency table

Factor B		Degrees of factor B						∑
Factor A		B_1	B_2	......	B_j	......	B_m	
Degrees of factor A	A_1	n_{11}	n_{12}	......	n_{1j}	......	n_{1m}	m_1
	A_2	n_{21}	n_{22}	......	n_{2j}	......	n_{2m}	m_2
	:	:	:		:		:	:.
	A_i	n_{i1}	n_{i2}	.....	n_{ij}	.....	n_{im}	m_i
	:	:	:		:		:	:.
	A_k	n_{k1}	n_{k2}	.....	n_{kj}	.....	n_{km}	m_k
∑		n_1	n_2	.....	n_j	.....	n_m	n

When there are two plural qualitative factors A, B, of which the first occurs in the variations (degrees) A_1, A_2, A_3, ... A_k and the second in the variations (degrees) B_1, B_2, B_3 ... B_m, their sorting forms $k \times m$ contingency table shown in Table **1**.

The degree of dependence between the plural form qualitative factors A, B is measured by comparing actual frequencies in particular stages of the contingency table n_{ij} with the expected multiplicity n'_{ij} assuming the independence of factors A, B. The expected dependences are calculated according to the equation:

$$n'_{ij} = \frac{n_i \cdot n_j}{n}.$$

They are calculated by multiplying of the marginal frequencies (n_i for factor A and n_j for B factor) range divided by a set of n.

The basis for the calculation is the quantity χ^2 (chi square), which is specified by the relationship:

$$\chi^2 = \sum_{i=1}^{k}\sum_{j=1}^{m}\frac{(n_{ij} - n'_{ij})^2}{n'_{ij}}.$$

The calculation of χ^2 is done directly in the contingency table, where the expected frequencies n'_{ij} or the differences $(n_{ij} - n'_{ij})$ are recorded in each grade (box table) except for the actual frequencies. Other symbols *n, k, m* are known from the text.

Expected frequencies must also be calculated for the table boxes where the actual frequencies are not occurring. The frequencies in the respective boxes enter the calculation of χ^2 with the value:

$$\frac{(0 - n'_{ij})^2}{n'_{ij}} = n'_{ij}.$$

The formula gives reliable results when the sample size is $n > 40$. If any of the frequencies in the contingency table is less than 5, the appropriate correction must be made in order to make the result reliable. The most advantageous correction is the one proposed by Yates (Myslivec, 1957, In Šmelko, Wolf, 1977) residing that we add the value of 0,5 to the minimum frequency and the other frequencies we adjuste in the way that the marginal frequencies remain unchanged. In the case that $20 < n < 40$ and any of the expected frequencies n'_{ij} is less than 5, the class in which the frequency is included should be merged with the neighboring (closest relative) class of A or B factor. For the range set $n < 20$ this methodology should not be used at all.

Variable χ^2 is the basis for a test of hypothesis about the independence of factors A and B. Its small values argue in favor of the hypothesis, the large values against the hypothesis.

In practice, the compliance with the asymptotic distribution is considered to be sufficient if $a_{ij} > 5\ \forall i,j$. If the $\chi^2 > \chi^2_{(k-1)(m-1)}(\alpha)$, the hypothesis of independence of factors A, B is rejected. The critical values of $\chi^2_{(k-1)(m-1)}(\alpha)$ are tabulated, while $(k-1)(m-1)$ represent the number of degrees of freedom.

Sometimes the χ^2 is also called the ratio of assurance. The value of χ^2 variable tells whether the dependency between factors A and B could be regarded as statistically significant or not. It does not say anything, however, about the dependence degree of these factors. The degree of dependence can be expressed by a coefficient of correlation of two plural qualitative factors A, B, which is calculated by the Čuprov formula (Urbach, In Šmelko, Wolf, 1977):

$$r_{AB} = \sqrt{\frac{\chi^2}{n \cdot \sqrt{(k-1)\cdot(m-1)}}}.$$

Findings. The subjects of the analysis were records of serious occupational accidents for the period 2000 – 2018 from selected forestry entities. Special attention was paid to the group of self-employed persons. A total of 141 fatal accidents at work and 345 serious accidents at work were statistically processed.

The number (n_{12}) of fatal accidents of self-employed is higher than the number (n_{11}) of fatal accidents of employees (Tab. 2). The number (n_{21}) of serious occupational accidents of employees exceeds the number (n_{22}) of serious occupational accidents self-employed persons almost three times. The higher number (n_{21}) of serious accidents of employees could also be caused by the serious occupational accidents classification system depending on the duration of sick leave (42 days), which was valid until the end of 2011. For the conformity testing of the serious occupational accidents of employees and self-employed risk contingent tables method was used (Table 2).

Table 2 – A risk assessment of serious occupational accidents of employees and self-employed (n_{ij} - actual frequencies, n'_{ij} - expected frequencies)

work accidents	number of injured employees	number of injured self-employed	sum
fatal	51 (n_{11})	90 (n_{12})	**141**
	93 (n'_{11})	48 (n'_{12})	
serious	268 (n_{21})	77 (n_{22})	**345**
	226 (n'_{21})	119 (n'_{22})	
sum	**319**	**167**	**486**

The null hypothesis formulation: The difference between the incidence of fatal accidents and serious accidents of employees and self-employed is statistically insignificant.

$\chi^2 = 76,47$; Degree of freedom (DF): 1

With the significance level 5% and the degree of freedom 1 the chi-square statistic table value is 3,8 ($\chi^2 > \chi^2_{1(0,05)}$), then we can state that we refuse the hypothesis with 95% probability. The difference between the incidence of fatal occupational accidents and serious occupational accidents of employees and self-employed is statistically significant. There were more fatal accidents at work of self-employed persons than expected (n'_{12}). The risk of fatal accidents at work for self-employed is higher than for employees. The association coefficient $r_{AB} = 0,397$ defines the degree of dependence as middle strong.

The most risky work phase is logging (Figure 1). There is also a very high risk of an accident at work during the yarding phase. In both phases, up to 75% of all fatal accidents were occurred.

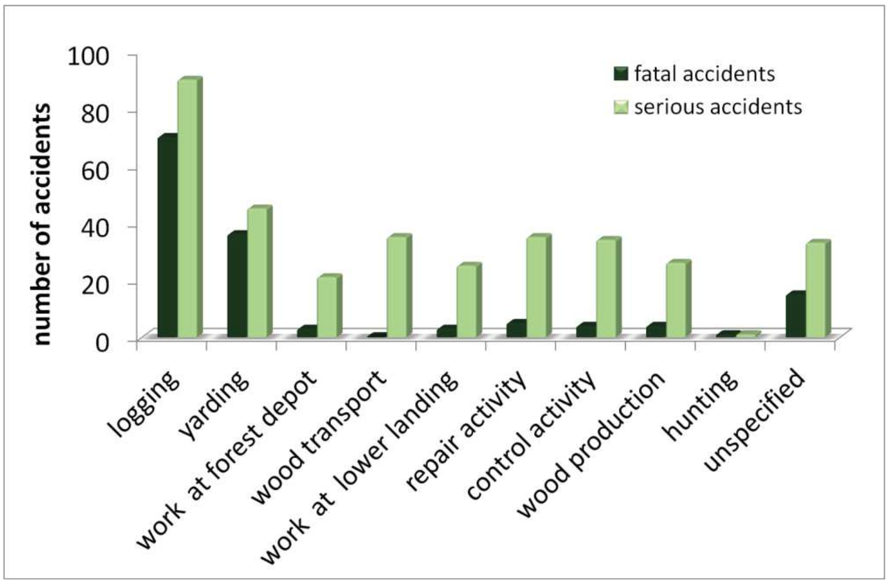

Figure 1 – The proportion of serious and fatal occupational accidents in specific work phases or activities

The most often injured body parts were the legs, with the 27% share of all analysed accidents. The second most often injured body part was the head (19% of all analysed accidents). Accidents of the torso and the hand were registered in 17% each. The category body includes the cases (16%), when more parts of body (e.g. the head and leg) were injured.

A contingency table (Table 3) was created to verify the statistical significance of fatal and serious occupational accidents of employees and self-employed due to cause 8 (use of dangerous procedures or work methods, including action without authorization, against orders, prohibitions and instructions, staying in the endangering area).

Table 3 – An assessment of difference in the occurrence of fatal and serious occupational accidents due to cause 8 (use of dangerous work methods) and cause 12 (work risk) (n_{ij} – actual frequencies, n'_{ij} – expected frequencies)

work accidents due to	number of injured employees	number of injured self-employed	sum
cause 8	95 (n_{11})	58 (n_{12})	153
	115 (n'_{11})	38 (n'_{12})	
cause 12	176 (n_{21})	30 (n_{22})	206
	156 (n'_{21})	50 (n'_{22})	
sum	271	88	359

The null hypothesis formulation: The difference in the occurrence of fatal and serious occupational accidents of employees and self-employed due to cause 8 and cause 12 (insufficiency of personal condition for solid job performance) is statistically insignificant.

$\chi^2 = 25,85$ Degree of freedom (DF): 1

At the significance level $\alpha = 0,05$ with a degree of freedom 1, the tabular value of the chi-square represents 3,8. The inequality $\chi^2 > \chi^2_{1\ (0.05)}$ holds, so we reject the stated null hypothesis at the chosen level of significance. The difference between the incidence of fatal and serious occupational accidents of employees and self-employed due to cause 8 and cause 12 is statistically significant. Cause 8 was the cause of serious work-related accidents of self-employed people more often than expected. The risk of injury while using unsafe practices by self-employed is higher than for employees. The association coefficient $r_{AB} = 0,268$ defines the degree of dependence as weak.

Discussion. Of the 141 fatal occupational accidents which were examined, up to 44 % were caused by the use of dangerous procedures or work methods, including unauthorized work, staying in the endangering area (cause 8). In the case of serious accidents at work two causes of accidents predominate. 180 accidents (52 %) occurred due to the lack of personal prerequisites for proper work performance - e.g. lack of physical condition, sensory deficiencies, adverse personal characteristics and immediate psychophysiological conditions (cause 12). Cause 12, which in practice is also called the common work risk, was represented by 18 % in fatal accidents. The second most common cause of serious accidents is cause 8, for example the unsafe practices use, which resulted in 26 % of accidents. The use of dangerous procedures at self-employed caused 41 % fatal work accidents and 27 % serious work accidents. The most significant cause of accidents at work in Polish forestry from 2009 to 2016 was the misconduct of employees in 57,9 % of cases (Golab, Krause, 2019).

Group V (fall of an object or material on person) is the most common source of fatal accidents at work in Slovakia with a share of 42%. The dominant events that caused accidents in forestry (Golab, Krause, 2019) were the impact of the object in motion (26,7%). Most accidents in Slovenia were caused by direct contact with parts of the tree (60%) (Potočnik et al., 2006). In the case of serious accidents at work in Slovakia, the largest proportions were injuries to the limbs (43%), but there were also injuries to the head (19%) and torso. The occurrence of fatal work accidents was caused mainly by injuries to several parts of the body. The incidence of fatal accidents as well as head and torso injuries had a decisive effect. Danilović et al. (2016) examined work accidents in forestry in Serbia from 2008 to 2012 and the most frequently damaged parts of the body were legs (38%) and shoulders (35%), the most common injury source was a branch (35%). According to Lefort et al. (2003) the most commonly injured part of the body was the knee (28%) and the most common injury source was hitting a falling object (25%).

Lawson et al. (2006) state that despite the introduction of harvester technologies, Newfoundland forestry has a high accident rate. There is an absence of a system of prevention, inspection, methodology and the impact of reducing the volume of mining. The author points to the need for specific actions and a coordinated approach by the government, health care institutions and researchers.

Effective tool for work accidents elimination is prevention. Prevent the work accidents occurrence in timber harvesting process we can mainly the following measures observance:

Working and rest behaviour observance – employers are obliged to set the working and rest behaviour.

Use of personal protective equipment - the role of the employer is to provide them and the role of employees is to use them and take care of them.

Selection of suitable technology - while not only the type of technology is important, but also its age and technical condition (noise and vibration level), the selection of suitable technology is conditioned by a number of factors and it is important that workers follow established work procedures.

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