Istraživanja i projektovanja za privredu
ISSN 1451-4117
DOI:10.5937/jaes0-37669
www.engineeringscience.rs

publishing

Journal of Applied Engineering Science
Vol. 20, No. 4, 2022
Original Scientific Paper
Paper number: 20(2022)4, 1024, 1196-1202

TRANSPORT AND MINING MACHINES OPERATORS' BEHAVIORAL ATTITUDES IN SAFETY CLIMATE CONTEXT

Vesna Spasojević Brkić[1], Zorica Veljković[1], Aleksandar Brkić[2], Mirjana Misita[1], Martina Perišić[1], Neda Papić[2]*

[1] University of Belgrade – Faculty of Mechanical Engineering, Kraljice Marije 16, 11000 Belgrade, Serbia
[2] Inovation Center of Faculty of Mechanical Engineering, Kraljice Marije 16, 11000 Belgrade, Serbia
* vspasojevic@mas.bg.ac.rs

As industrial systems represent a complex socio-technical system, it is necessary to analyse the impact of manager-operator-machine interaction on industrial safety, as categories of contextual factors. However, modern scientific literature indicates insufficient research on this topic. This paper has an aim to empirically analyse behavioural style and transport and mining machines operators' attitudes in the safety climate context. Participants in this study were 28 crane's and 65 mining machinery's (excavators, bucket wheel excavators, bulldozers, loaders, graders, backhoe loaders, trenchers, dump trucks and scrapers) operators working in Serbian industrial companies. In the first step there is conducted descriptive statistics and followed by Kolmogorov's and U Mann-Whitney test to examine differences. Obtained results have shown that there were not statistically significant differences both between attitudes of operators on those two kinds of machines, namely, there are no statistically significant differences in terms of absenteeism due to poor working conditions, atmosphere of cooperation and togetherness among operators and the ways in which managers motivate and reward them. Between numbers of injuries at work happened by both machines' types used there are no statistical differences, too. Also, further factor analysis has shown that examined operators' and machines' characteristics divide into two factors – one is focused to anthropometric characteristics presented by height and weight while another is focused on age of operator and machine and operator's experience. It is recommended, in future research to enlarge sample, repeat statistical testing and analyse wider set of variables on examined matters in aim to discover pattern of anthropometric factors influence on behavioural factors.*

Keywords: F operator, transport machine, mining machine, statistical analysis

1 INTRODUCTION

As industrial systems represent a complex socio-technical system, it is necessary to investigate the impact of manager-operator-machine interaction on industrial safety, as categories of contextual factors, however, modern scientific literature indicates insufficient research on this topic and shows very limited impact of technical facts on technical standards and norms. On the other hand, it is known that regulatory requirements will give adequate results only if the needs of users of industrial machinery and equipment at all hierarchical levels are taken into account, despite the difficulties and complexities in their identification and quantification. Certainly, the safety of employees at work is a prerequisite for any private activity.

Therefore, the safety management of employees at work, i.e., workplaces, is considered as an integral part of the production management system. The traditional approach to security management is closely focused on technical factors such as the design of machinery, tools and equipment, as well as security policies and procedures. The same technique for improving (maintaining) the state of safety at work has been known in the world since the beginning of the industry, however, in the science of management there are much later attempts to systematize the factors that affect the safety of employees in the workplace. In other words, compliance with the procedure and rules for the safe conduct of work activities is not sufficient in order to achieve full safety of employees. According to the Zohar and his first research [1], in the process of managing safety at work, the essence is, as he puts it, the culture of safety and the climate of safety. These two terms are equated in many works of different researchers, but there are also key distinctions between these terms. Leadership style is a very important factor, significantly influencing organizational and safety culture and climate [2].

This paper has an aim to empirically analyze leadership style and transport and mining machines' operators attitudes in safety climate context. It is structured as follows. After topic introduction in this section, literature, which in narrow topic defined here is scarce, and its review is given in the next section, while in the third section methodology is described, implemented and results are given, while the last, forth section gives discussion and conclusions.

2 LITERATURE REVIEW

Available literature although at the first glance seems wide, rarely examines the topic of this paper. Safety culture is part of the organizational culture and tends to focus on deeper and harder to access core values and assumptions within the organization in terms of safety and human resources in general [3]. On the other hand, according to one definition, the safety climate is seen as a special attribute consisting of two factors: the commitment of safety management and employee participation in meeting security requirements [4]. According to this definition, it can be said that the safety climate defines the subjects in achieving the goal (safety), as well as their frameworks of action. On the other hand, safety culture is a term that describes ways to manage safety in the workplace. In addition, the safety culture reflects the attitudes, beliefs, perceptions and values related to safety, which employees share within the organization [5]. Again, according to some authors such as in [6] and [7], the terms safety culture and safety climate simply merge in their interrelationships, so they should be viewed as such. In recent times, the focus has been on consistency of behavior in terms of compliance with safety rules and regulations. However, this is not entirely enough to reduce the risk of injury, so the emphasis is on proactive action by individuals [8]. The safety climate serves as a framework of references for employees in terms of a sense of safety in the workplace and the adjustment of personal behavior in accordance with safety measures [9]. Individual perception of safety climate influences employee behavior. On the other hand, group attitudes within an organization can have an impact on individual perceptions and behaviors [10]. The concept of safety climate has been studied for more than 30 years [11]-[17]. The study of the safety climate is based on the common perception of employees in terms of organizational policies, procedures and practices, and in relation to the values and importance of safety within the organization. [18]-[20]. Therefore, it can be said that the safety climate is a component of the safety culture, which is again part of the organizational culture. [21]-[24]. Also, there is an attitude in the literature that the safety climate is a reflection of the prevailing safety culture within the organization [25]. Safety climate is a key indicator of accidents and injuries at work [26], and the mechanism through which this is achieved is the impact of safety climate on employee motivation, as well as their knowledge and ability to perform work activities in a safe manner [24]. Safer employee behavior results in a reduction in the number of accidents and injuries at work. [12], [27]. Numerous literature sources suggest that organizational leadership is linked to a wide variety of employee outcomes, both positive and negative, relevant to occupational health and safety [28]- [30].

This study is aimed to check if there are statistically significant differences in attitudes between crane's and mining machinery's (excavators, bucket wheel excavators, bulldozers, loaders, graders, backhoe loaders, trenchers, dump trucks and scrapers) operators on leadership style, number of injuries and operators' behavior in sense of sick leave and absenteeism matters. Also, influential factors, such as age, height, weight and work experience of the operator as well as the age of the machine he is operating, on those matters will be searched.

3 METHODOLOGY AND RESULTS

3.1 Methodology

Participants for this study were randomly selected from the general populations of crane's and mining machinery's (excavators, bucket wheel excavators, bulldozers, loaders, graders, backhoe loaders, trenchers, dump trucks and scrapers) operators in Serbian industrial companies. Their task was to give data about the following:

- Age of operator
- Height
- Weight
- Operator's work experience
- Age of the machine,

and to give answers on Likert 1-5 scale on the following questions:

1. Q1 - Due to poor working conditions I am often absent from work (medical leave)
2. Q2 - There is an atmosphere of cooperation and togetherness among mechanization operators
3. Q3 - Leaders motivate and reward us.

In the first part of this study, descriptive statistics were conducted for 65 operators of mining machinery and 28 operators of transport machinery, and data from descriptive statistics on operators (age of operator, height, weight, work experience and age of the machine) are shown in Tables 1 and 2. The second part of the research refers to the factor analysis of the researched factors of operator characteristics, and the third part presents the comparison of data obtained in the survey for operators of transport and mining machinery (answers to questions about management style and absenteeism). The aim was to have insight into the general overview of the survey data as well as to determine the type of comparison that will be performed, i.e. parametric or non-parametric, as well as to draw relevant conclusions in this, today, insufficiently researched field.

3.2 Results and data analysis

In the first step is conducted descriptive statistics. Descriptive statistics show sample sizes, means, medians, minimum and maximum, range, standard deviation, and variation coefficient expressed as a percentage. In case the variation coefficient is greater than 30%, the variable is inhomogeneous so that it conditions the use of nonparametric statistics. Otherwise, the Kolmogorov test for normality was additionally performed, where the tables show the test d and p values for the Kolmogorov test. Finally, it is determined whether the variable type is parametric or nonparametric. Descriptive statistics on examined questions, e. In the first step is conducted descriptive statistics. Descriptive statistics show sample sizes, means, medians, minimum and maximum, range, standard deviation, and variation coefficient expressed as a percentage. In case the variation coefficient is greater than 30%, the variable is inhomogeneous so that it conditions the use of nonparametric statistics. Otherwise, the Kolmogorov test for normality was additionally performed, where the tables show the test d and p values for the Kolmogorov test. Finally, it is determined whether the variable type is parametric or nonparametric. Descriptive statistics on examined questions, e.g. answers given by operators is given in Table 3.g. answers given by operators is given in Table 3.

Table 1: Descriptive statistics on mining machines operators

Statistic	Age of operator	Height	Weight	Work experience	Age of the machine
N	65	65	65	65	65
Min	19.000	166.000	60.000	1.000	1.000
Max	54.000	190.000	150.000	38.000	13.000
R	35.000	24.000	90.000	37.000	12.000
Med	35.000	180.000	90.000	9.000	5.000
Mean	34.846	179.415	91.092	10.631	5.708
Var (n)	74.776	31.843	277.161	93.864	15.622
Var (n-1)	75.945	32.340	281.491	95.330	15.866
SD (n)	8.647	5.643	16.648	9.688	3.952
SD (n-1)	8.715	5.687	16.778	9.764	3.983
cv	0.248	0.031	0.183	0.911	0.692

Table 2: Descriptive statistics on transport machines operators

Statistic	Age of operator	Height	Weight	Work experience	Age of the machine
N	28	28	28	28	27
Min	33.000	165.000	70.000	12.000	0.120
Max	55.000	182.000	102.000	32.000	40.000
R	22.000	17.000	32.000	20.000	39.880
Med	50.000	176.000	83.000	22.000	40.000
Mean	46.393	173.679	87.786	20.964	35.301
Var (n)	65.739	34.504	125.811	45.177	86.043
Var (n-1)	68.173	35.782	130.471	46.851	89.353
SD (n)	8.108	5.874	11.217	6.721	9.276
SD (n-1)	8.257	5.982	11.422	6.845	9.453
cv	0.175	0.034	0.128	0.321	0.263

Table 3: Descriptive statistics on examined questions

	N	Mean	Med	Min	Max	R	SD	cv (%)	d	p	variable
QK1	28	1.871	2.000	1.000	4.000	3.000	0.922	49.261			nonparametric
QK2	28	3.935	4.000	2.000	5.000	3.000	0.998	25.355	0.21285	< 0.10	parametric
QK3	28	2.000	2.000	1.000	5.000	4.000	1.000	50.000			nonparametric
QB1	65	1.631	1.000	1.000	5.000	4.000	1.294	79.34			nonparametric
QB2	65	3.892	4.000	1.000	5.000	4.000	1.134	29.12	0.23575	< 0.01	nonparametric
QB3	64	2.875	3.000	1.000	5.000	4.000	1.351	46.99			nonparametric

The comparison of the answers of the operators of transport and mining machinery to individual questions was performed via the U* Mann-Whitney test, since no answer of the operators of mining machinery behaves according to the normal distribution (Table 1). The data of this comparison are shown in Table 4. The last data compared between transport and mining machinery operators are injuries, for which proportions were used, where it was shown that 16,129% of transport machinery operators had injuries, while that number at mining machinery operators was 13.846%. The comparison showed that this difference was not statistically significant, since the p-level of the test was 0.7205.

Table 4: Comparison of answers to individual survey questions between transport and mining machinery operators

Transport machinery operators		Mining machinery operators	U*	Z*	p	level of significance
QK1	=	*QB1*	*36.500*	*-0.179*	*0.858*	*n.s.*
QK2	=	*QB2*	*13.000*	*0.990*	*0.322*	*n.s.*
QK3	=	*QB3*	*36.000*	*0.735*	*0.462*	*n.s.*

A comparison of individual questions between transport and mining mechanization operators indicates that there are no statistically significant differences in the answers. That is, both categories of operators provided similar answers to the considered questions. If all three questions are considered in summary and the Z test is applied for the difference of the environments, it is also obtained that there are no significant differences, as in Table 5.

Then, a factor analysis of the data on all operators was conducted, in order to investigate the way of their grouping. In Table 6 correlation analysis is shown, while the rotated matrix of components is shown in Table 7. Data in Table 7 indicate the fact that the data are divided into two factors - the first factor is the age of operator, work experience of the operator and the age of the machine he operates, while the second factor is factors related to anthropometric characteristics - height and weight of the operator.

Table 5: Comparison of the answers of the operator of transport and mining machinery according to the answers for the group of questions

			Z	*p*	level of significance
Transport machinery operator	=	*Mining machinery operator*	0.977	0.326	n.s.

Table 6: Correlation Matrix on operator and machine characteristics

r		Age of operator	Height	Weight	Work experience	Age of the machine
Correlation	Age of operator	1.000	-0.487	-0.047	0.883	0.448
	Height	-0.487	1.000	0.413	-0.462	-0.306
	Weight	-0.047	0.413	1.000	-0.122	-0.092
	Work experience	0.883	-0.462	-0.122	1.000	0.411
	Age of the machine	0.448	-0.306	-0.092	0.411	1.000
Sig. (1-tailed)	Age of operator		0.000	0.321	0.000	0.000
	Height	0.000		0.000	0.000	0.001
	Weight	0.321	0.000		0.111	0.179
	Work experience	0.000	0.000	0.111		0.000
	Age of the machine	0.000	0.001	0.179	0.000	

Table 7: Rotated Component Matrix on operator and machine characteristics

Rotated Component Matrix				
	Raw		Rescaled	
	Component		Component	
	1	2	1	2
Age of operator	7.925	-0.597	0.806	-0.061
Height	-2.759	2.824	-0.347	0.558
Weight	0.032	14.982	0.002	0.998
Work experience	7.552	-1.347	0.770	-0.137
Age of the machine	12.601	-1.145	0.872	-0.079
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.				

4 CONCLUSION

This is one of rare studies focused on leadership style and transport and mining machines' operator's attitudes in the safety climate context and Serbian operators' population. This study examined 65 mining machinery and 28 transport machinery operators and came to the following conclusions:

- The comparison of transport and mining machinery operators' answers to individual questions was performed using the Mann-Whitney U* test, since none of the mining machinery operators' answers behaves according to normal distribution and shows that there are no statistically significant differences in absence issues due to poor working conditions, the atmosphere of cooperation and togetherness among mechanization operators and the ways in which managers motivate and reward them;
- Overall, for all three parameters there are also no statistically significant differences;
- Although 16,129% of transport machinery operators suffered injuries, while the number of mining machinery operators was 13,846%, the comparison showed that this difference was not statistically significant, given that the p-level of the test is 0.7205;
- Finally, a factor analysis was performed to divide the data into two factors - the first factor is the age of operator, work experience of operator and the age of the machine he operates, while the second factor is factors related to anthropometric characteristics - height and weight of the operator.

According to this study, using parametric and non-parametric methods, has been shown that there are no evidenced statistically significant differences between subjects, so machines and equipment which are controlled by means of Serbian operator could be designed in the same manner both for workers in transport and mining industry. Further factor analysis points out to the importance of anthropometric characteristics in design, on one side, and of age of both operator and machine and operator experience.

It is recommended, in future research to enlarge sample and repeat statistical testing. Further analysis on anthropometric characteristics of operators is advised. Also, it is recommended to include variables such as leadership development and certain forms of training.

5 ACKNOWLEDGEMENT

The paper is supported by grants from the Ministry of Education, Science and Technological Development, grants from project E!13300, RESMOD Safera and contract 451-03-68/2022-14/200105 (subproject TR 35017). The authors also thank participants for their cooperation.

6 REFERENCES

[1] Zohar, D. (1980). Safety climate in industrial organizations: theoretical and applied implications. Journal of applied psychology 65(1), 96-102.

[2] Choudhry, R. M., Fang, D., & Mohamed, S. (2007). The nature of safety culture: A survey of the state-of-the-art. Safety science, 45(10), 993-1012.

[3] Wiegmann, D. A., Rich, A., & Zhang, H. (2001). Automated diagnostic aids: The effects of aid reliability on users' trust and reliance. Theoretical Issues in Ergonomics Science, 2(4), 352-367.

[4] Dedobbeleer, N., & Béland, F. (1991). A safety climate measure for construction sites. Journal of safety research, 22(2), 97-103.

[5] Cox, S., & Cox, T. (1991). The structure of employee attitudes to safety: A European example. Work & stress, 5(2), 93-106.

[6] Mearns, K. J., & Flin, R. (1999). Assessing the state of organizational safety—culture or climate?. Current psychology, 18(1), 5-17.

[7] Lin, S. H., Tang, W. J., Miao, J. Y., Wang, Z. M., & Wang, P. X. (2008). Safety climate measurement at workplace in China: A validity and reliability assessment. Safety Science, 46(7), 1037-1046.

[8] Xuesheng, D., & Xintao, Z. (2011). An empirical investigation of the influence of safety climate on safety citizenship behavior in coal mine. Procedia engineering, 26, 2173-2180

[9] Xu, Y., Li, Y., Wang, G., Yuan, X., Ding, W., & Shen, Z. (2014). Attentional bias toward safety predicts safety behaviors. Accident Analysis & Prevention, 71, 144-153.

[10] Tholén, S. L., Pousette, A., & Törner, M. (2013). Causal relations between psychosocial conditions, safety climate and safety behaviour–A multi-level investigation. Safety science, 55, 62-69.

[11] Zohar, D. (2010). Thirty years of safety climate research: Reflections and future directions. Accident analysis & prevention, 42(5), 1517-1522.

[12] Alruqi, W. M., Hallowell, M. R., & Techera, U. (2018). Safety climate dimensions and their relationship to construction safety performance: A meta-analytic review. Safety science, 109, 165-173.

[13] Lyu, S., Hon, C. K., Chan, A. P., Wong, F. K., & Javed, A. A. (2018). Relationships among safety climate, safety behavior, and safety outcomes for ethnic minority construction workers. International journal of environmental research and public health, 15(3), 484.

[14] Pandit, B., Albert, A., Patil, Y., & Al-Bayati, A. J. (2019). Impact of safety climate on hazard recognition and safety risk perception. Safety science, 113, 44-53.

[15] Kim, N. K., Rahim, N. F. A., Iranmanesh, M., & Foroughi, B. (2019). The role of the safety climate in the successful implementation of safety management systems. Safety science, 118, 48-56.

[16] Zadow, A., Dollard, M. F., Parker, L., & Storey, K. (2019). Psychosocial safety climate: a review of the evidence. Psychosocial Safety Climate, 31-75.

[17] Kalteh, H. O., Mortazavi, S. B., Mohammadi, E., & Salesi, M. (2021). The relationship between safety culture and safety climate and safety performance: a systematic review. International journal of occupational safety and ergonomics, 27(1), 206-216.

[18] Oah, S., Na, R., & Moon, K. (2018). The influence of safety climate, safety leadership, workload, and accident experiences on risk perception: A study of Korean manufacturing workers. Safety and health at work, 9(4), 427-433.

[19] Lee, J., Huang, Y. H., Cheung, J. H., Chen, Z., & Shaw, W. S. (2019). A systematic review of the safety climate intervention literature: Past trends and future directions. Journal of occupational health psychology, 24(1), 66.

[20] Chen, H., Li, H., & Goh, Y. M. (2021). A review of construction safety climate: definitions, factors, relationship with safety behavior and research agenda. Safety science, 142, 105391.

[21] Glendon A. I. & Stanton N.A (2000). Perspectives on safety culture. Safety Science, Vol. 34 pp 193-214

[22] Zohar, D. (2003). Safety climate: Conceptual and measurement issues. In J. C. Quick & L. E. Tetrick (Eds.), Handbook of occupational health psychology (pp. 123–142). American Psychological Association.

[23] Cooper, M.D. and Phillips, R.A. (2004) Exploratory Analysis of the Safety Climate and Safety Behavior Relationship. Journal of Safety Research, 35, 497-512.

[24] Kalteh, H. O., Mortazavi, S. B., Mohammadi, E., & Salesi, M. (2021). The relationship between safety culture and safety climate and safety performance: a systematic review. International journal of occupational safety and ergonomics, 27(1), 206-216.

[25] Casey, T. W., Hu, X., Reid, C., Tran, P. A., & Guldenmund, F. W. (2022). Rolling up our sleeves and pulling up our socks: A critical review of safety culture definitions and measures, and innovative ways to move the field forward. Handbook of Research Methods for Organisational Culture.)

[26] Abubakar, A. M., Karadal, H., Bayighomog, S. W., & Merdan, E. (2018). Workplace injuries, safety climate and behaviors: application of an artificial neural network. International journal of occupational safety and ergonomics

[27] He, C., McCabe, B., Jia, G., & Sun, J. (2020). Effects of safety climate and safety behavior on safety outcomes between supervisors and construction workers. Journal of construction engineering and management, 146(1), 04019092.).

[28] Kelloway, E. K., & Barling, J. (2010). Leadership development as an intervention in occupational health psychology. Work & Stress, 24(3), 260-279.

[29] Spasojević-Brkić, V., Veljković, Z., Essdai, A. A., & Brkić, A. (2019). Differences in anthropometric measurements between Libyan and Serbian passenger car drivers and crane operators. Journal of Applied Engineering Science, vol. 17, no. 1, 1-7, DOI: 10.5937/jaes17-19969

[30] Spasojević-Brkić, V. K., Veljković, Z., & Brkić, A. (2015). Crane Cabins's Safety and Ergonomics Characteristics Evaluation Based on Data Collected in Sweden Port. Journal of Applied Engineering Science, vol. 13, no. 4, 299-306, DOI: 10.5937/jaes13-9564

7 NOMENCLATURE

Abbreviation	
N	sample size
Med	Median
Min	minimal value
Max	maximal value
Var	variance
R	Range

Abbreviation	
SD	standard deviation
cv	coefficient of variation
D	Kolmogorov statistics
p	P-value
Sig.	significance
n.s.	not significant
r	coefficient of correlation
U	U Mann Whitney test
Z	Z-statistics
p	significance level

Paper submitted: 03.05.2022.
Paper accepted: 25.05.2022.