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PRIORITIZATION AND ASSESSMENT OF SAFETY KEY PERFORMANCE INDICATORS IN AN AUTOMOTIVE INDUSTRY

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SUMMARY: The performance of any management system needs to be monitored with adequate and proper indicators. This study aimed to identify, set priorities and assess key indicators for implementing an effective performance evaluation system. This descriptive-analytical study was carried out in three phase. In first phase, a semi-structured interview as well as a review of the company's documentation and studies carried out, then a set of key indicators were collected and selected. The validity of the indicators were determined by experts (N = 11) and indicators were prioritized using Analytic Hierarchy Process (AHP) according to SMART (Specific, Measurable, Achievable, Relevant, and Time- bound) criteria. Following the study framework, a primary set of 60 Key Performance Indicators (KPIs) were collected. The results of the validity assessment showed 23 indicators had acceptable validity. The results of examining the relationships between the indicators showed that the percentage of corrected non- compliance and the number of risk assessments had a significant relationships with the total number of work-related lost time injuries as a lagging indicator. According to the results, the four the most important key performance indicators to assess the safety performance in the automotive industry were as follows: the number of risk assessments conducted, the percentage of corrected non- compliance, the percentage of safety educational programs implemented for workers, and Frequency Severity Index (FSI) index.

Key words: *occupational safety, safety management, safety, Analytic Hierarchy Process (AHP)*

INTRODUCTION

The automotive industry has been identified as one of the most, hazardous industries with regard to the workers' health and safety *(Petruni et al., 2017)*. In this industry, due to the use of heavy machinery, its diversity, the management policies governing it in terms of the number of vehicles manufactured per hour, scheduling work cycles and so on, there are always numerous occupational accidents *(Clarke, 2006)*. Occupational accidents are the third leading cause of death in the world and the second leading cause of death in Iran *(Vosoughi et al., 2019)*. Improve the safety performance of the industry, decrease and remove the workplace event is most important *(Stemn et al., 2019)*. Today, the Occupational Health and Safety Management System (OHS-MS) has been established in most industries. This system and the safety management system include the methods, roles and practices related to safety that have been created with the aim of eliminating or

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reducing occupational risks *(Fernández-Muñiz et al., 2012)*. Safety performance is defined as actions or behaviors that people do in almost all occupations to promote the health and safety of workers, customers, and the general public *(Nadhim et al., 2016)*. There are at least three reasons for safety measurement: (i) Benchmarking, (ii) communication with stakeholders (iii) and internal improvement process *(Harrington et al., 2009)*. By measuring safety performance, the company's current status in terms of safety management can be determined. Knowing this status will help predict future problems and prevent damage that may occur to the individuals or any type of special equipment *(Matooq and Suliman, 2013)*. According to Cambon et al. *(2006)*, there are three main approaches to performance measurement: (i) result-based approach (ii), compliance-based approach (iii), and process-based approach. The result-based approach seeks the results of the system over the past periods (incidents, occupational illnesses, etc.). This approach is widely used, but does not evaluate the operational and structural aspects of the systems. The compliance-based approach involves an audit of the compliance degree of the management system with existing management standards. However, auditing is focused on the "structural" part of the system. Despite some visits and inspections in different work fields, auditing does not fully address the system's impact on the work environment and organizational conditions. The process-based approach measures the performance of each management process (policies, safety plans, etc.) forming the system. The priority of the process-based approach is the operational performance of the management system *(Cambon et al., 2006)*. The performance of any management system needs to be monitored with adequate and proper indicators *(Mohammadfam et al., 2016)*. Measuring indicators can be divided into two Types: (i) leading indicators and (ii) lagging indicators *(Awolusi and Marks, 2016)*. Performance measurement indicators are found in numerous studies, but in practice, it is not possible to consider them all because it needs spending a lot of time and training the staff to collect information, and the existence of a large variety of information makes decision-making more difficult and reduces its quality. Hence, reducing the information and taking into account the key indicators seem necessary when making important decisions. Decision-making problems appear when the important indicators which represent other indicators are going to be selected among a number of operational ones, and the following questions arise: which of the KPIs should be selected from a set of performance indicators? How should these indicators be prioritized to consider the most important one? In this regard, what criteria are needed for the evaluation and selection of the most important KPIs? A series of criteria has been specified by the SMART acronym which is used to evaluate and select a set of KPIs. The letters of SMART respectively stand for Specific, Measurable, Achievable, Relevant, and T Time- bound. There are also a lot of multiple criteria decision making methods to prioritize performance indicators *(Podgórski, 2015)*. These methods are important in decision making for occupational safety systems *(Janackovic et al., 2017)*. A review of related studies showed that the most popular and most used method was analytic hierarchy process (AHP) *(Petruni et al., 2017, Chong et al., 2017)*. This method has a low level of complexity and it used to solve the problems involving more than one decision-making criterion *(Koulinas et al., 2019)*. This method has been used in various studies to select key performance indicators for OHS-MS *(Podgórski, 2015)*. Risk-based maintenance policy selection *(Arnuraj and Maiti, 2010)*, risk assessment *(Kokangül et al., 2017)*, safety management system *(Hsu et al., 2015)*, select the safety devices *(Caputo et al., 2013)*. Also, AHP was used to prioritizing KPIs in this research project. Regarding the important role of occupational safety in continuous improvement of any organization, it is necessary to create a set of specific key indicators for establishing an effective system for measurement and evaluation of performance. In this automotive industry, due to the large number of indicators, lack of prioritization of important indicators and their impact on statistical indicators of accidents, we decided to conduct this study. Therefore, this study aimed to identify, prioritization and assessment key indicators for implementing an effective performance evaluation system in an automotive industry.

METHOD

An overview of the research methodology

This study is a descriptive-analytical applied research carried out in four phases. In this study, according to the subject, a brainstorming session was used to extract the research questions. We used the following Research questions to help us to focus on the goals research.

Research Questions:

(1) What indicators can be used to evaluate the performance of the safety management system, given the organization's status in terms of occupational safety risk management? What kind of them can improve a safety performance?

(2) What indicators are used by automotive companies or other organizations to evaluate the performance? What types of indicators and approaches for performance evaluation have been recommended by the studies and guidelines?

(3) Which types of indicators do experts consider necessary according to the industry's situation, and which ones have acceptable content validity?

(4) Which of the suggested indicators are in the top priority?

(5) Are we getting better or worse over time?

Phase 1. Identification of Key Indicators

Performance measurement should be done according to the industry's status and internal requirements. For proper selection and effective use of key indicators, the current situation needs to be assessed to identify the weaknesses and do improvements.

Stage 1. Semi-Structured Interviews

To answer the first research questions, some safety experts were first interviewed by the researcher, so that the required information could be obtained *(Almost et al., 2018)*. Semi-structured interviewing has been used in many safety scientific literature *(Goode et al., 2019, Ju et al., 2018, McLinton et al., 2018)*. In this study, a purposive non-random (predetermined) sampling method was used to select the experts. The advantages of the non-random method was that only experts with sufficient experience were selected *(Sinelnikov et al., 2015)*. The selection of a diverse group of experts was necessary to ensure the credibility, transparency, reliability and suitability of the process *(Jasiński et al., 2016)*. Tongco *(2007)* argued that in order to ensure the data reliability in a purposive sampling, there needed to be at least 5 experts. Guest et al. *(2006)* also suggested that the sample size of 6 to 12 experts was usually sufficient. In this study the samples included the OHS consultant (N=5), internal safety auditors (N=4), the director of the occupational safety Office of the organization (N=1), and two senior experts from the Industrial Health Office (N=2). All experts had more than 7 years of work experience.

Demographic characteristics of participants (experts) in this study are shown in Table 1. Each interview lasted for about 30 to 60 minutes. The researcher collected the data (suggested indicators and the points to be taken into account) after each face-to-face interview. All interviews were recorded and put into written word by word. Then the line-by-line coding and content analysis were applied *(Forsberg, 2016)*. The output of the interview was a set of indicators that were coded and extracted from the interview texts.

Table 1. Demographic characteristics of participants in the expert survey

Tablica 1. Demografske karakteristike sudionika u stručnoj anketi

Variable	Category	Frequency	Survey (%)
Age	30-40	8	62.23
	40<	4	30.76
Level of Education	Master of sciences	8	61.53
	Associate Professor	4	38.46
	7-12	4	30.76
work experience	12-17	5	38.46
	>17	3	30.76
	auditor	4	30.76
Type work	OHS officer	4	30.76
	Academic staff	4	38.46

Stage 2. Documentation review (recent evaluations) and Scientific literature

In order to answer questions 2, Scientific literature and educational guidelines as well as the annual reports of automobile companies were reviewed *(Sinelnikov et al., 2015, Swuste et al., 2016, Antão et al., 2016, Yan et al., 2017, Mohammadfam et al., 2016, Pawłowska, 2015, Vosoughiet al., 2015)*. An initial set of related indicators was then extracted, and the following guidelines were also reviewed: IOGP[1], ASCC[2], HSE[3], and IOSH[4].

Phase 2. Developing a set of primary KPIs and Assessing the Content Validity of KPIs

At this phase, according to the results of the first phase a set of primary KPIs was collected. To assess the content validity of primary KPIs, the comments given by 11 Experts (7 Safety Auditors and 4 university ones) were used. To this end, a questionnaire was developed and the experts were asked to consider the indicators based on a three-point Likert scale, as follows, in order to evaluate the performance in a car manufacturing factory: "the indicator is necessary", "the indicator is useful, but not necessary", and "the indicator is not necessary". Then a formula was used to calculate CVR. To this purpose, the experts identified "relevance", "clarity" and "simplicity" of each item based on a 4-part Likert spectrum. The minimum acceptable value for the CVI indicator was 0.79. In this study, the indicators whose CVI was lower than 0.79 were eliminated *(Vosoughi et al., 2020)*.

The Content Validity Ratio (CVR) and Content Validity Index (CVI) using Eq. 1 and 2 were calculated *(Polit and Beck, 2006)*.

$$CVR = \frac{n_e - \frac{N}{2}}{N \div 2} \qquad [1]$$

$$CVR = \frac{\text{The number of experts that given a rating of 3 or 4 to items}}{\text{N}} \qquad [2]$$

n_e = Total number of experts saying item is essential

N = Total number of experts

[1]The International Association of Oil & Gas Producers

[2]Australian Safety and Compensation Council

[3]Health and Safety Executive

[4]Institution of Occupational Safety and Health

Phase 3. Prioritization of the Key Indicators Using the AHP Method

The AHP allows for the relative weight of the variants to be calculated using the opinions of all experts. AHP can be implemented in 5 stages: (i) construction of a hierarchical model (Figure 1); (ii) pairwise comparison of the criteria; (iii) pairwise comparison of decision variants according to the main criteria. At this stage, in order to determine the weights of the variants, they were compared two by two and scored by the experts; (iv) measuring the consistency rate of the paired comparisons; and (v) prioritizing decision variants and determining the best ones *(Sipahi and Timor, 2010)*. In AHP, scoring the criteria or indicators that are compared pairwise is done using the 9-point scale (1 = Equally Preferred, 3 = Moderately Preferred, 5 = Strong, 5 = Strongly Preferred, 7 = Very Strongly Preferred, 9 = Extremely Preferred, 2,4,6,8 = Intermediate value) *(Petruni et al., 2017)*. In a paired comparison matrix, the comparisons with a consistency rate of less than 0.1 (CR <0.1) are valid and the paired comparisons can be trusted. In this study, the paired comparison matrices were sent to 12 experts (academic ones and Safety Auditors). Then, to aggregate the paired comparison matrices obtained from the experts, all the data from consistency matrices (CR <0.1) were aggregated using geometric mean. Expert Choice software perform the AHP Method and it's a decision-making software *(Podgórski, 2015)*. The results of the aggregated matrices were analyzed using Expert Choice software (V11).

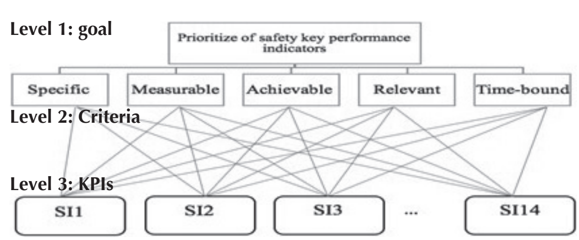

Figure 1. A hierarchical structure for prioritizing KPIs of occupational health

Slika 1. Hijerarhijska struktura za prioritizaciju KPI-a radne terapije

Phase 4. Evaluation of suggested indicators in an automotive industry

This study was conducted in the largest automobile companies in Iran. To find out the relationship of indicators and to answer the five research questions, we extracted information on a number of indicators over a decade (see Table 2). Indicator information were extracted from company's information management system by three safety auditors. Other indicators information were not fully available in 2009 to 2018. To investigate the relationship of indicators, first normality of the data were investigated then both Pearson correlation test and Spearman correlation test were used for abnormal data.

RESULTS

Results of phase 1

To identify the indicators after the interviews, a set of KPIs was proposed, and was added to the list of primary KPIs. The university professionals mostly emphasized the leading indicators, while those working in the automotive industry emphasized the lagging indicators.

The results of reviewing the documentations demonstrated that the gaps were chiefly due to the operational dimensions of the OHS management system. In addition to reviewing the documentations, various studies as well as the relevant guidelines and annual reports of several automobile companies were reviewed. A set of indicators reported from these companies are listed in Table 3 *(PSA Groupe, 2016, General motors…, 2016, Ford, 2016, Torras, 2016, Zetsche, 2016)*. Furthermore, the results of reviewing the guidelines and related studies showed that both the leading and lagging indicators had to be used *(ASCC, 2005, Lingard et al., 2013, Janackovic et al., 2013)*. Therefore, regarding the steps taken in this study, the result-based and the process-based approaches were considered for selecting the indicators.

Table 2. A number of safety index for an automotive industry 2009–2018.

Tablica 2. Broj indeksa sigurnosti za automobilsku industriju 2009.-2018.

Year	Number of risk assessments conducted	The percentage of corrected non-compliance	Frequency severity indicator	Man Hour Training In Newly Hired Employees	The Total Number of Work-Related Lost Time Injuries	Percentage of the Total Number of Work-Related Lost Time Injuries Reduction Compared to the Previous Year	The Percentage of Safety Educational Programs Implemented
2009	1997	52.60	0.096	42000	640	4.48	63.78
2010	2110	60.83	0.010	58000	565	11.72	53.06
2011	2330	53.59	0.087	41000	752	-33.10	48.47
2012	2700	50.11	0.120	35000	509	32.31	65.82
2013	2710	58.46	0.054	51000	362	28.88	56.12
2014	2725	53.76	0.059	45000	401	-10.77	50.51
2015	2730	58.35	0.032	54000	221	44.89	66.33
2016	2755	58.90	0.031	55600	193	12.67	61.73
2017	2770	63.07	0.022	61800	139	27.98	67.35
2018	2977	69.42	0.013	79000	38	72.66	71.43

Table 3. Occupational Safety Indicators used in some reports of automotive companies
Tablica 3. Indikatori radne terapije korišteni u nekim izvješćima automobilskih tvrtki

Ford General Motors and Benz	PSA Group: French automotive manufacturer and ZANINI AUTO GRUP
1. The number of lost days in all branches throughout the world, compared to 100 employees	12. Total lost time due to events
2. The number of workers who are absent due to an accident in each shift.	13. Number of audits carried out
3. The number of workers who are absent due to exposure to toxic substances in each shift.	14. Total number of training hours
4. The ratio of safety covers and showers per workers	15. The number of educational policies implemented
5. Number of safety assessments done	16. Meetings are held and the relationship between management and staff through OHS Committees
6. Number of safe devices	17. Knowledge of OHS
7. Participation in safety education	18. Hours of annual training per employee
8. Related safety courses are held and certificates provided	19.Number of events in one year
9. The amount of participation in education	20. Number of lost days due to accident
10. Missed work time due to occupational accidents	21. AFR
11. Deaths due to occupational accidents	

Results of Phase 2

Following the study framework for the selection of KPIs, a primary set of indicators (N=70) were collected. The results of the validity assessment showed that among the 45 safety KPIs and 17 educational ones, 14 and 9 indicators had acceptable validity, respectively (Table 4).

Table 4. The results of the validity and final weight of each indicator
Tablica 4. Rezultati valjanosti i konačne težine svakog indikatora

		Indicators	CVI	CVR	The final weight	Rank
Safety Indicators	SI1	The total number of work-related lost time injuries (TNW-RLT).	0.87	0.63	0.027	12
	SI2	Frequency Severity Index (FSI).	0.87	0.63	0.104	4
	SI3	Number of injury per employee.	0.84	0.63	0.054	8
	SI4	The frequency of similar events in the same process.	0.87	0.63	0.029	11
	SI5	Average cost per injury.	0.84	0.63	0.026	13
	SI6	Lost workday per worker.	0.87	0.63	0.035	10
	SI7	The Percentage of the Total Number of Work-Related Lost Time Injuries Reduction compared to previous year.	0.84	0.63	0.050	9
	SI8	The number of near miss that recorded and analyzed	0.90	0.81	0.029	11
	SI9	The Percentage of budget allocated for risk management	0.87	0.63	0.113	3
	SI10	The percentage of corrected non- compliance (detected in internal and external audits - after inspection and assessment).	0.84	0.63	0.082	7
	SI11	Number of risk assessments conducted.	0.90	0.81	0.136	1
	SI12	The number of maneuvers carried out.	0.87	0.63	0.130	2
	SI13	safety Climate.	0.84	0.63	0.096	5
	SI14	Safety audits (number of annual internal and external audits).	0.90	0.63	0.090	6
Educational Indicators	EI1	educational investment per company's GDP.	0.81	0.90	0.206	2
	EI2	Man Hour Training In newly hired employees.	0.81	0.84	0.067	7
	EI3	Percentage of trained supervisors within a year.	0.63	0.84	0.082	5
	EI4	Percentage of trained managers within a year.	0.81	0.87	0.044	9
	EI5	Percentage of workers who have been trained emergency procedures, including relief and rescue activities and first aid.	0.81	0.90	0.112	4
	EI6	Number of Safety educational courses provided by contractors to workers.	0.63	0.84	0.049	8
	EI7	percent of job training programs for workers that has been implemented.	0.81	0.87	0.215	1
	EI8	percent increase in training hours.	0.81	0.87	0.155	3
	EI9	The number of e-learning programs that have been held.	0.63	0.84	0.081	6

Results of phase 3

According to results of prioritization Criteria, relevance and specificity Criteria with the weights of 0.36 and 0.23 were the first and second priorities, respectively, and achievability and measurability Criteria with the weight of 0.16 were the third. Besides, being time-bound Criteria was ranked fourth. The results of prioritizing the indicators are presented in Table 4 and show that the number of risk assessments conducted with a weight of 0.136 was the first priority. The number of maneuvers carried out had a weight of 0/130 and was in the second priority. The third and fourth priorities were the Percentage of budget allocated for risk management and FSI with the weights of 0/113 and 0/104. Also, among the educational indicators and based on the obtained weights, the percentage of safety educational programs implemented, educational investment per company's GDP, and the percent of increased training hours were the first, second and third priorities with the weights of 0/215, 0/206 and 0/155, respectively.

Results of phase 4

The results of the correlation analysis between the indicators are presented in Table 5.

Table 5. Correlation between Indicators
Tablica 5. Korelacija između indikatora

Variable	1	2	3	4	5	6	7
1- NRAC	-	-	-	-	-	-	-
2- PCN-C	0.55	-	-	-	-	-	-
3- FSI	-0.394	-0.87**	-	-	-	-	-
4-MHT	-	-	-0.323	-	-	-	-
6- TNW-RLTI	-0.815**	-0.76*	0.66*	-0.17	-	-	-
7- PTNW-RLTIRE	0.64*	0.64*	-0.41	0.39	-	-	-
8-PISTP	-	-	-0.17	-	-0.66*	0.83**	-

Notes. NRAC - Number of Risk Assessments Conducted, PCN-C - The percentage of corrected non- compliance, FSI- Frequency Severity Index, MHT- Man Hour Training In newly hired employees, TNW-RLTI- Total Number of Work-Related Lost Time Injuries, PTNW-RLTIRE - Percentage of the Total Number of Work-Related Lost Time Injuries Reduction Compared to the Previous Year , PISTP-Percentage of Implemented Safety Training Programs,

** Correlation is significant at the 0.01 level ($p < 0.01$), * Correlation is significant at the 0.05 level ($p < 0.05$).

According to Table 5, the Pearson correlation test showed a negative and significant correlation between the percentage of corrected non- compliance and the FSI ($R = 0.87$, $p < 0.001$). There was also a negative and significant relationship between the percentage of corrected non-compliance and the TNW-RLTI index ($r = -0.76$, $P = 0.010$). There was also a positive and significant relationship between the TNW-RLTI index and the FSI index ($r = 0.66$, $P = 0.03$). Other results of the correlation analysis showed a negative and significant correlation between the number of risk assessments performed and the TNW-RLTI index ($R = -0.85$, $p < 0.004$). The correlation between educational indicators and lagging indicators was also investigated. Among the educational indicators, the percentage of safety educational programs implemented for workers was found to have a negative and significant correlation with the TNW-RLTI index ($r = -0.66$, $P = 0.03$). To compare the indices, their scores were standardized and ranged from zero to 100. The Changes in five indicators (Number of Risk Assessments Conducted, The percentage of corrected non- compliance index, FSI index, the total number of work-related lost time injuries and The Percentage of implemented safety training programs index) are shown in Fig. 2 and show that an increase in the leading indicators led to a decrease in lagging indicators (FSI index and the total number of work-related lost time injuries).

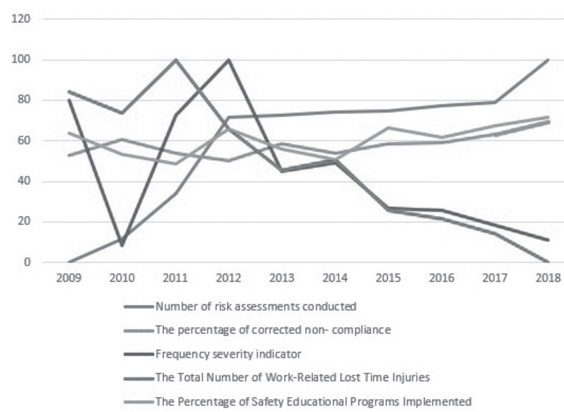

Figure 2. Changes in five indicators: Number of Risk Assessments Conducted, The percentage of corrected non- compliance index, FSI index, the total number of work-related lost time injuries and The Percentage of implemented safety training programs index in an automotive industry 2009–2018.

Slika 2. Promjene u pet indikatora: broj provedenih procjena rizika, postotak ispravljenog rizika neusklađenosti, FSI indeks, ukupan broj ozljeda na radu zbog izgubljenog vremena te indeks provedenih programa osposobljavanja za sigurnost u automobilskoj industriji 2009.-2018.

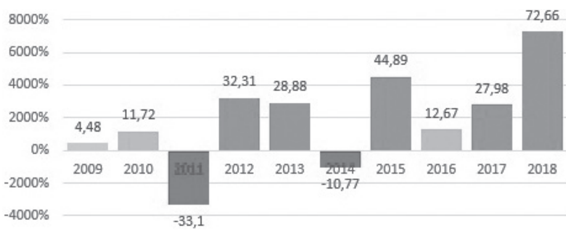

Figure 3. The total number percentage of work-related lost time injuries reduction compared to the previous year index in an automotive industry 2009–2018.

Slika 3. Postotak ukupnog broja smanjenja ozljeda na radu zbog izgubljenog vremena u odnosu na indeks prethodne godine u automobilskoj industriji 2009.-2018.

Also, we found a positive and significant relationship between the number of risk assessments performed and the percentage of TNW-RLTI reduction compared to the previous year (r = 0.64, P = 0.04). Figure 3 shows the percentage of TNW-RLTI reduction compared to previous years in 2009-2018. According to Figure 3, the highest percentage of TNW-RLTI reduction compared to the previous year was observed in 2018, but in 2011 and 2014, there was no reduction in TNW-RLTI index compared to the previous years; on the contrary, it had increased. Besides, the results of Table 5 show that there was a positive and significant relationship between the percentage of corrective actions carried out and the percentage of TNW-RLTI reduction (r = 0.64, P = 0.04). In addition, the percentage of safety programs implemented for workers had a positive and significant correlation with the percentage of reduction in the TNW-RLTI index compared to the previous year (r = 0.83, p = 0.003) (Table 5). There was no significant correlation between the percentage of safety educational programs implemented for workers and the FSI index (r = 0.17, p = 0.63). Furthermore, no significant relationship was found between the training man-hour of the newly employed personnel and the FSI index (r = -0.323, P = 0.36). It did not have a significant correlation with the TNW-RLTI index, either. (r = -0.17, P = 0.62) (Table 5).

DISCUSSION

Identification, Developing a set of primary KPIs and Assessing the Content Validity of KPIs

Initially, a semi-structured interview was conducted to identify the status of the organization. The results showed that managers and industrial technicians mainly focused on lagging indicators, and this was probably due to the specific features of these indicators, despite the limitations, because they were easily collected, understood, and used for benchmarking. In addition to the interviews, reviewing the documents was carried out. Following the first phase led to extraction of 43 safety performance indicators. Having assessed the content validity of the safety performance indicators, we selected 14 ones with acceptable validity. The selected indicators were SMART indicators. The indicators can periodically and effectively help to identify improvement needs, set the goals, and evaluate the intended interventions. The reports in the articles showed that the key indicators were needed to be taken into consideration. This was also considered in the present study, and only the key indicators were selected by the expert team according to the current situation *(Mazri et al., 2012)*. The proposed indicators were based on the operational dimensions of OHS-MS. The operational dimensions showed the impact of the OHS system on the work environment. Following the operational indicators would provide some information on progression and improvement changes in the system and might be helpful for planning *(Podgórski, 2015)*. The indicators selected in this study were a combination of both types of indicators. The effectiveness of ongoing efforts related to OHS could be evaluated by monitoring the lagging indicators and this is why they are important *(Matooq and Suliman, 2013)*. However, they provide little information about the causes of the incident *(Guo and Yiu, 2013)*. In addition, we need to have an accurate reporting and recording system *(Adl et al., 2012)*. Research has shown that the use of leading indicators might help to further develop preventive safety plans *(Wurzelbacher and Jin, 2011)*. It could also provide an assessment based on a comparison between actual performance and planned performance. A combination of the two types of indicators in safety performance assessment can help overcome the constraints of each type *(Hopkins, 2006)*, and provide more comprehensive data *(Lingard et al., 2017)*. In the study by Podgorski *(2015)*, only the leading indicators were proposed for all industries. In the study by, Liu et al. *(2014)* only selected the leading indicators in the semiconductor industry. But in this study, the indicators were of both types and were selected according to the internal needs. In Lingard study, he considered the status of the industry and proposed a three-level structure including the leading and lagging indicators as well as the safety climate. He suggested that such a combination would provide a significant depth. In our study, the safety climate has also been considered. In Lingard's study *(2013)*, the quantitativeness of the indicators was not considered and the indicators with a higher priority were not specified. But in the present study, the indicators with SMART Criteria were prioritized. In addition, this study not only emphasized the operational safety performance indicators, but also the performance of related educational activities in this area. Following the phase 1 and 2, we suggested 17 safety-related educational indicators, 12 of which had an acceptable content validity and were selected for prioritization. Several studies also considered the training of the personnel and supervisors as a leading indicator *(Almost et al., 2018, Vredenburgh, 2002, Pawłowska, 2015)*. Various car manufacturing performance reports also focused on OHS training indicators (Table 3). Pawłowska *(2015)* studied the indicators used to evaluate the OHS performance in 60 industries and the results showed that the leading indicators such as OHS training and risk assessments, the number of non-compliances, and the number of workstations that were better managed against risks had a strong and significant relationship with OHS performance. It should be noted that the Guide to Occupational OHS Standards, such as Clause 3-4 of ILO-OSH, Clauses 4-4-2 of OHSAS18001, and ISO 45001, addressed the training and specification of risk-based educational needs. In the study by Podgorski *(2015)*, argued that it would be better to use fewer indicators to be able to manage the key indicators more easily. This was also considered in the present study and from among 43 safety indicators and 17 educational ones, 14 and 9 indicators were selected respectively.

Prioritization, Evaluation of the KPIs and correlation between indicators

The results of prioritization using the AHP method showed that most of the leading indicators were in top priorities compared to the lagging ones, which is in line with the results of the study by Janackovic et al. *(2013, 2017)*. The results of examining the correlation between the indicators showed that the leading indicators of the percentage of percentage of corrected non- compliance and the number of risk assessments performed had a negative and significant relationship with the TNW-RLTI lagging indicator. Moreover, there was a negative and significant relationship between the percentage of non-conformities dissolved and the FSI index, but no significant relationship was found between the number of risk assessments performed and the FSI index ($r = -0.394$, $P = 0.26$). In the study by Zofia Pawłowska *(2015)*, there was a significant difference between the accident rates in the companies that used the leading indicator of the "Number of Risk Assessments Performed" and those that did not. This is in line with the results of the present study. Regarding other leading indicators, the percentage of safety educational programs implemented for workers had a negative and significant relationship with the TNW-RLTI index ($r = -0.66$, $P = 0.03$), showing that an increased percentage of conducting educational programs would decrease the TNW-RLTI index. In the study by Pinto et al. *(2011)*, the lack of adequate education as well as poor safety knowledge of senior managers and project managers were reported as the root cause, affecting safety performance. Besides, some studies provided strong evidence on the effect of training on safety behaviors *(Robson et al., 2012)*. Recent studies have shown that OHS training is one of the most important tools for preventing occupational injuries, risks and diseases *(Faigenbaum and Myer, 2010, Vidal-Gomel, 2017)*. Some studies have also shown that long-term follow up of leading indicators at the site-level can reduce incident rates *(Sinelnikov, 2015)*. The results of the study by Rajaprasad *(2016)* showed that the total man-hour education, the number of near miss, the number of accidents, and the allocated budget had a positive relationship with the accident rate. The results of this study are consistent with those of the studies by Ansari et al. *(2016)*, Omidvari et al. *(2011)* and Patrick and Yorio *(Wachter, 2014)*. In the study of Patrick and Yorio, there was a significant relationship between safety system practice and incident rates *(Wachter, 2014)*. In their studies, Ansari et al. *(2016)* and Omidvari et al. *(2011)* stated that implementing safety programs had a positive impact on the reduction of accident indicators, which was seen as a decrease in the following indicators: ASR, AFR, FSI, and repetitive occupational diseases *(Ansari et al., 2016, Omidvari et al., 2011)*.

CONCLUSION

An appropriate definition of performance indicators in safety management systems can help improve the monitoring process and well indicates the changes compared to previous years, depending on the type of industry. Also, safety performance indicators provide a good tool for management to control the role of safety on accidents while controlling the safety unit performance. According to the results of this study, the four the most important key performance indicators to assess the safety performance in the automotive industry were as follows: the number of risk assessments conducted, the percentage of corrected non- compliance, the percentage of safety educational programs implemented for workers, and FSI. These indicators could be specifically used in the automotive industry in order to implement an effective performance evaluation system to achieve occupational safety goals and programs with the approach of the effectiveness of the activities.

Limitations of the study, recommendations for further research

It is better to select the main performance indicators and confirm them by more OHS experts. The selected indicators should be followed in other automotive companies to confirm their effectiveness in evaluating and improving performance. Using only the AHP method when we have a lot of measurement indicators will increase the number of pair comparisons. In further research to reduce the number of pair comparisons, it would be better to combine this method with other methods, such as Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

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PRIORITIZACIJA I PROCJENA SIGURNOSNIH KLJUČNIH POKAZATELJA USPJEŠNOSTI U AUTOMOBILSKOJ INDUSTRIJI

SAŽETAK: Učinkovitost bilo kojeg sustava upravljanja treba pratiti odgovarajućim i ispravnim pokazateljima. Cilj ove studije bio je identificirati, odrediti prioritete i procijeniti ključne pokazatelje za primjenu učinkovitog sustava vrednovanja učinka. Ovo opisno-analitičko istraživanje provedeno je u tri faze. U prvoj fazi, polustrukturirani intervju, kao i pregled provedene dokumentacije i studija tvrtke, zatim je prikupljen i odabran skup ključnih pokazatelja. Valjanost pokazatelja odredili su stručnjaci (N = 11), a pokazatelji su odredili prioritete pomoću Analitičkog postupka hijerarhije (AHP) prema SMART (Specifični, mjerljivi, dostižni, relevantni i vremenski ograničeni) kriteriji. Slijedom okvira studije, prikupljen je primarni skup od 60 KPI. Rezultati procjene valjanosti pokazali su da 23 pokazatelja imaju prihvatljivu valjanost. Rezultati ispitivanja odnosa između pokazatelja pokazali su da je postotak ispravljene neusaglašenosti i broj procjena rizika u značajnoj vezi s ukupnim brojem ozljeda izgubljenog na radu kao pokazatelj zaostajanja. Prema rezultatima, četiri najvažnija ključna pokazatelja uspješnosti za procjenu sigurnosnih performansi u automobilskoj industriji bila su sljedeća: broj provedenih procjena rizika, postotak ispravljenih nesukladnosti, postotak provedenih obrazovnih programa o sigurnosti za radnike i indeks FSI.

Ključne riječi: *zaštita na radu, upravljanje sigurnošću, sigurnost, analitički hijerarhijski postupak (AHP)*

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