Identification, Selection and Prioritization of Key Performance Indicators for the Improvement of Occupational Health (Case Study: An Automotive Company)

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Abstract: Regarding the important role of occupational health in the continuous improvement of organizations, the aim of this study was to identify, select and prioritize key indicators for improvement of occupational health in an automotive company. This cross-sectional descriptive study was carried out in three stages. First, a semi-structured interview as well as an inspection and a review of the company’s documentation and studies were carried out, and a set of key indicators were identified and selected. Then, the validity of the indicators were determined by experts (N = 11). Following that, the indicators were prioritized based on SMART criteria. Following the study framework, we collected a set of indicators that included 45 health indicators and 17 educational ones. The results of examining their content validity showed that among the 45 primary health indicators and 17 educational ones, 12 and 9 indicators had acceptable validity, respectively, and a total of 21 indicators were suggested for the purpose of the study by the expert team. The results of prioritizing showed that the leading indicator such as the percentage of corrective and preventive health actions done with the weight of 0.146 was the first priority. A set of key indicators was proposed according to the results, based on the objective of the study, which can help managers and industrial hygiene experts to assess performance in the automotive industry.

Keywords: occupational health, health, identification, industry.

(Received May 21, 2019, accepted January 24, 2020)

Introduction

Workers’ health and safety might guarantee economic development and health in society, and is an important component of development [1]. The automotive industry is one of the most important industries in the manufacturing sector, and an important pillar of the global economy. About 5% of the world’s workforce is directly or indirectly working in this industry [2]. The automotive industry in Iran has grown dramatically in recent years. Due to the use of heavy machinery, the diversity in the industry and the management policies governing it in terms of the number of vehicles produced per hour, the size of the workforce, scheduling work cycles, etc., the automotive industry has always been taken into consideration in terms of the number...
of work-related accidents and illnesses [3].

The Occupational Health and Safety Management System (OHS-MS) has been established in most workplaces and industries in order to maintain the health of the staff [4]. In order to achieve the goals of the OHS-MS and the satisfaction of the beneficiaries, OHS risks must be controlled. Effective control of risks occurs when the OHS-MS is effective [5, 6]. Performance measurement is a tool for measuring effectiveness and continuous improvement, and its main goal is to convert the measured data into some information for access to effectiveness and efficiency of the activities [7]. According to Cambon et al., there are three main approaches to the measurement of OSH-MS performance: (1) a result-based approach, (2) a compliance-based approach, and (3) a process-based approach.

The result-based approach searches for the results of the system over the past time (incidents, occupational illnesses, etc.). This approach is widely used because it is easy to implement and does not require much time or money. However, it does not assess the operational and structural aspects of the systems.

The compliance-based approach involves an audit of the degree to which the management system complies 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 [8].

Performance measurement is a process that periodically follows the selected performance indicators associated with the goals of a company [9]. In order to measure the specific aspects of occupational health performance, it is necessary to define operational indicators [5]. According to Öztas et al., system performance should be monitored with appropriate indicators; otherwise, investments would be wasted [10]. Toellner suggested that indicators could be classified into two categories: (1) leading indicators measuring preventive actions, and (2) lagging indicators associated with results and outcomes [11]. A number of leading and lagging indicators have been suggested in previous studies for the measurement of the performance of occupational health, but in practice, taking into account all the indicators requires spending time and training the personnel in order to collect information. On the other hand, the existence of large amounts of information and the diversity of it makes decision-making more difficult and the quality of managerial decisions will be reduced. Hence, one should try to reduce the information and consider key indicators once important decisions are made [12]. Also, gathering too much information may result in the inefficiency of the performance evaluation system, and it is best to start with a few operational indicators and do further measurements during OHS-MS maturity [5].

Key Performance Indicators (KPIs) are used to monitor the progress of a company over time or to compare the results of companies [13]. The most important stage of measuring the system performance is the selection of a criteria for performance indicators [9]. 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 Time-bound (Table 1) [14, 12]. There are many Multiple-Criteria Decision Making Methods (MCDMs) that may be used to select and prioritize performance indicators from among a set of performance indicators [12]. Reviewing published articles on the use of MCDMs revealed that the most popular and most commonly used method was Analytic Hierarchy Process (AHP) [12], developed by Saaty [15]. It is not too complicated and can be used to solve problems that involve more than one decision-making criterion. Taking into account different criteria, AHP calculates the weight and priority of decision variants. This method
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has been used in various studies in order to select the key performance indicators of the OHS-MS [12], determine the weight of the key performance indicators and sub-indicators of the safety management system [16, 17], weigh the factors affecting musculoskeletal disorders (29), select key indicators for sustainable development [18, 19], and many others [20, 21]. Also, due to the fact that in AHP, weighing the variants is done by paired comparison of the variants with the target, and the variants are evaluated and scored through comparison with each criterion involved in the paired comparison, this method is efficient for the present study and the final results have higher accuracy and reliability. It is also less complicated than other methods, including fuzzy ones. Hence, it was used to prioritize KPIs in the present study due to its advantages.

Regarding the mentioned issues and the important role of occupational health in the continuous improvement of any organization, it is necessary to create a set of key and specific indicators for establishing a system for measurement and evaluation of performance in the automotive industry. This study therefore aimed to identify, select and prioritize key indicators for improvement of occupational health in the automotive industry.

Methods

This is an applied, descriptive-analytical study. The aim of the present study was to identify, select and prioritize KPIs of occupational health in a car factory. The study was conducted in three phases.

Table 1. Definition of SMART Criteria

| Criteria  | Definition |
|-----------|------------|
| Specific  | The name of the indicator should precisely define the phenomenon under research, and should be comprehensive and appropriate for the measurement. |
| Measurable | It should be possible to measure the indicator’s value based on a properly selected unit. Data for the measurement should be identifiable and readily available. The indicator should provide appropriate accuracy and repeatability of the measurement. |
| Achievable | The resources (human and financial, etc.) necessary for the gathering of information should be sufficient. |
| Relevant  | Measurement using the indicator should contribute to accomplishing the general objectives of a given system, process or action. The indicator should be relevant to the operation of an enterprise or organizational unit or a part of a company. |
| Time-bound | It should be possible to determine the period in which a given value of the indicator may be achieved. |

Research Questions:

1) What indicators can be used to evaluate the performance of the occupational health management system, given the organization’s status in terms of occupational health risk management?
2) In the current situation, what kind of indicators can improve a company’s conditions?
3) What indicators are used by automotive companies or other organizations to evaluate performance?
4) What types of indicators and approaches for performance evaluation have been recommended by the studies and guidelines?
5) Which types of indicators do experts consider necessary according to the company’s situation, and which ones have acceptable content validity?
6) Which of the suggested indicators are in the top priority?

Phase 1: Identification of Key Indicators

Performance measurement has to be mainly consistent with domestic needs, and should be done according to the company’s status and internal requirements. Kaplan stated that each organization has to measure the indicators and functions that reflect the unique strategies of the organization [6]. In this study, in order to identify the indicators, the organization’s status was first examined using a semi-structured interview, targeted inspections, and internal documentation review. Also, to develop the initial set, the selected key indicators of similar industries as well as the studies carried out were evaluated.
**Stage 1: Semi-structured interview**

To answer the first and second research questions, some industrial hygiene specialists were first interviewed by the researcher, so that the required information could be obtained [22]. The semi-structured interview was conducted in order to obtain the answers to the pre-defined questions and to provide an opportunity for the specialists to express their experiences of health performance assessment if they wished. Semi-structured interviewing has been used in various OHS research areas [22–24]. The specialists were selected through non-random purposive sampling (predetermined), and the individuals who were in the best position to provide the required information were selected. The advantage of non-random sampling was that only qualified and experienced professionals were selected [25]. In the present study, the views of 12 active experts were used during the semi-structured interview. All participants had more than 10 years of work experience in the car manufacturing industry. The study was conducted in one of the largest vehicle manufacturers in Iran as well as the Middle East. The participants included OHS consultants (N=2), internal audit (health) officials (N=5), the director of the occupational health office of the organization (N=1), and four senior experts from the Industrial Health Office (N=4). 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.

**Stage 2: Inspection of workstations**

In this study, the Elmeri observation method was used to analyze the workstations of this automotive factory, taking into account the safety and health aspects. The Elmeri observation method is a preventive measure based on the assessment of the workplace, working conditions, and workers’ behavior [26], and is used to evaluate OHS. This method is based on the observation of the workstation. The observed aspects cover all dimensions of machinery safety, industrial hygiene, and ergonomics. It consists of 7 main items and 26 sub-items. The main items include safety behaviors, order and discipline, safety of machinery, industrial hygiene, ergonomics, passages, and first aid and fire safety. Various items are observed at each workstation according to the aspects of the workplace. When the observed issue is in accordance with OHS standards ‘Correct’ points are given; when an issue is not in accordance with standards, ‘Incorrect’ points are given. The percentage of correct points is accepted as the Elmeri index, also known as the Elmeri score. Therefore, Elmeri creates an index by monitoring the present standard in the workstation. The Elmeri index can range from 0% to 100%. For instance, 60% index means 60 of each 100 observed issues are in accordance with work OHS standards and workplace implementations. A higher score on the Elmeri index reflects more compliance with health and safety standards[27]. In this study first, to verify the accuracy of the information collected, a checklist whose content validity was confirmed by 13 OHS experts was used. Then, in order to verify the reliability of the checklist, 6 stations were separately evaluated and scored by 3 evaluators, and the intra-class correlation (ICC) was calculated. The observation steps were as follows:

**Step 1: Creating an observing team**

Before applying the method, a five-member team led by the research executive was formed. The team consisted of three OHS masters and one OHS Ph.D. Once the team was formed, several sessions were held by the executive to train the members how to observe the workstations according to the guidelines of the Elmeri method.

**Step 2: Selection of the workstations for observation**

The workstations to be observed were selected so that reliable results could be achieved and various tasks of each hall could be covered. In this study, 4 body-making rooms, 4 assembly rooms, 3 paint rooms and 3 press rooms were selected. Regarding the research objective and the number of workstations in the manufacturing rooms, the Cochran formula was used and the sample size of 323 was determined with 5% precision of the Elmeri index and 95% confidence level. The stations were selected through simple random sampling.

**Step 3: Observe the workstations based on Elmeri checklists**

After selecting the workstations in two different pe-
periods of time, the selected stations were observed on the basis of the Elmeri checklists. If any observed case was compliant with safety standards, it was considered all right; otherwise, it indicated non-compliance.

Stage 3: Examining the documentations and measurements done on occupational health

At this stage, the documentation of the latest measurements and evaluations carried out, as well as the internal audit documentations, were reviewed.

Stage 4: Reviewing scientific studies and related educational guidelines

In order to answer questions 3 and 4, the studies and guidelines related to performance evaluation as well as the annual reports of automobile companies were reviewed. The most important of these studies included the ones conducted by Podgórski [12], Swuste et al [28], Antão et al [29], Yan et al [30], Sinelnikov et al [25], Öztaş et al [10], Yarahmadi et al [31], Pawłowska [32], and Vosoughi et al [33], etc. An initial set of related indicators was then extracted, and the following guidelines were also reviewed: The International Association of Oil & Gas Producers (IOGP) [34], Australian Safety and Compensation Council (ASCC) [5] and Health and Safety Executive (HSE) [6].

Phase 2: Selection of KPIs

Stage 1: Developing a set of primary key indicators

At this stage, a set of key indicators related to industrial hygiene was developed according to the conducted interviews and observations, as well as the review of the documentations, studies, and guidelines on performance evaluation.

Stage 2: Creating an expert team and assessing the content validity of primary key indicators

To assess the content validity of the collected indicators, the comments given by 11 specialists (7 automotive industry specialists and 4 university ones) were used. The Content Validity Ratio (CVR) and Content Validity Index (CVI) were calculated to determine the content validity quantitatively. To this end, a questionnaire was developed and the specialists were asked to consider the research objective and questions (question 5), and to classify 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. The Waltz & Bausell method was also used to assess CVI [35]. To this purpose, the specialists 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. CVR and CVI using Eq. 1 and 2 were calculated [36].

\[ CVR = \frac{n_e}{\frac{N}{2}} \]  

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

where 

- \(n_e\) = The total number of experts that had expressed items is essential. 
- \(N\) = Total number of experts.

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

Analytic Hierarchy Process (AHP) is a MCDM method in which group decision-making is possible, and a group of decision-makers can give opinions on different decision variants with regard to a qualitative criterion. The AHP allows for the relative weight of the variants to be calculated using the opinions of all the decision makers. Since this method is based on a paired comparison, it simplifies judgment and calculations, and indicates the degree of consistency and inconsistency of the decisions. This is one of the advantages of this method in MCDM [37]. AHP can be implemented in 5 stages: (1) construction of a hierarchical model of varied criteria and options (Fig. 1); (2) pairwise comparison of the criteria in the form of reciprocal matrices and sending them to the expert team and determine the weight of each criterion; (3) pairwise comparison of decision variants according to the main criteria in the form of reciprocal matrices and sending them to the expert team and determine the weight of each decision variant. At this stage, in order to determine the weights of the variants, they are compared two by two and scored by the experts, and finally, the consistent matrices are aggregated using the
geometric mean, and their relative weights are calculated; (4) measuring the consistency rate of the paired comparisons; and (5) prioritizing decision variants and determining the best ones [38, 39]. In AHP, scoring the criteria or variants that are compared pairwise is done using the 9-point scale proposed by Saaty (1 = Equal, 3 = Moderate, 5 = Strong, 6 = Very Strong, 9 = Extremely Strong) [37]. In a paired comparison matrix, the comparisons with a consistency rate (CR) of less than 0.1 (CR <0.1) are valid and the paired comparisons can be trusted. In AHP analysis for calculation of CR, we should first calculate the consistency index (CI). The CI and CR for each comparison matrix were calculated, using Eq. 3 and 4.

\[
CI = \frac{\lambda_{max} - R}{n-1} \quad (3)
\]

\[
CR = \frac{CI}{RI} \quad (4)
\]

The eigenvalues of matrix of paired comparisons where \(\lambda_{max}\) is the maximum matrix eigenvalue of paired comparisons, \(n\) is the number of criteria or variants, and RI is the random index, the value of which is determined depending on the matrix dimension \(n\) on the basis of a table as proposed by Saaty [15]. However, in the case of non-consistency of the paired comparisons done by the experts, some revision will be needed. In this study, the paired comparison matrices were sent to 10 specialists (academic ones and those working in the automotive industry). Then, to aggregate the paired comparison matrices obtained from the specialists, all the data from compliant matrices (CR <0.1) were aggregated using geometric mean [40]. The results of the aggregated matrices were analyzed using Excel software (Microsoft, WA), and the final weights of the criteria and key indicators were extracted.

**Results**

**Results of phase 1**

To identify the indicators after the interviews, a set of performance indicators was proposed for health performance assessment, and was added to the list of primary indicators. The university professionals mainly emphasized the leading indicators for performance evaluation, while those working in the automotive industry emphasized the lagging indicators because of the ease of collecting information and the objective aspect of such indicators. They were not interested in indicators such as a safe and health climate or the attitude of the personnel, due to self-reporting and having mental concepts as well as the need for a lot of resources and time to collect the indicators. In addition to conducting interviews, the workstations were also observed. Before the commencement of the observations, the validity and reliability of the checklist were examined. In general, the checklist items had good validity. Once the validity was checked, the checklist was examined for reliability, and the ICC (intraclass correlation) of 0.810 was obtained, which confirmed its reliability. The results of the observations showed that in the press rooms, 80% of the observed stations had a sound level higher than 85 dB. In the paint rooms, the personal protective equipment (PPE) use and risk-taking criteria in 92.3% of the workstations were not in accordance with standards and pro-

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**Fig. 1. A hierarchical structure for prioritizing key performance indicators (KPIs) of occupational health.** HI: health indicators.
cedures, and during the observations, the workers had behaviors such as working without an individual protection mask, or removing the mask and talking with colleagues while painting the car bodies. This was due to the lack of awareness of the health hazards in the rooms. Ergonomic problems were more in assembly rooms, and 41.17 work stations observed had contradictions in terms of the station design and posturing. Body-making rooms had the highest levels of noncompliance (Table 2).

In Table 2, the Elmeri index calculated based on the percentage of correct observed items (in accordance with the standard) can be seen. As shown in the table above, the analysis of variance showed that there was a significant difference between the mean Elmeri of different rooms. Also, the post hoc tests indicated that this difference was due to the difference between the mean Elmeri score of the body room and that of the other rooms ($P <0.001$), so that the mean Elmeri score of that room was at least 10 points lower than that of other rooms, and the lowest mean Elmeri score was that of the body-making room.

The results of reviewing the documentations showed that the problems and gaps were mainly due to the functional dimensions of the OHS management system. For example, reviewing the noise measurement documents in the press rooms showed that more than 50 percent of the personnel working in the press rooms were exposed to sound intensities higher than 82 dB during 8 hours of daily work. It shows the failure to do required controls at the workstations.

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 [41–45]. Furthermore, the results of reviewing the guidelines and related studies showed that both the leading and lagging indicators had to be used

| Table 2. Comparison of the mean Elmeri scores in different manufacturing rooms |
|---------------------------------|--------|--------|--------|--------|--------|--------|
| Groups             | number | Minimum Elmeri index% | Maximum Elmeri index% | Mean Elmeri index% | Standard deviation Elmeri index% | Test statistic | p-value |
| Press              | 3      | 70     | 95     | 81.32 | 8.37   | 9.535  | <0.001 |
| Paint              | 3      | 66.66  | 95     | 82.46 | 7.58   |        |        |
| Assembly           | 4      | 65.21  | 95.4   | 80.86 | 8.15   |        |        |
| Body making        | 3      | 59     | 90     | 72.96 | 9.50   |        |        |

| Table 3. Occupational health indicators used in some reports of automotive companies |
|---------------------------------|--------|---------------------------------|
| French automotive manufacturer | Zanini Auto Group, Benz, Ford | General Motors |
| 1. Total lost time due to events | 7. Meetings are held and communication between management and staff through the safety and health committees | 13. Lead levels in staff blood |
| 2. Frequency of occupational diseases | 8. Level of safety awareness | 14. Participation in health education |
| 3. Frequency of occupational stress | 9. Annual Training Hours per employee | 15. Health courses that are held and certified. |
| 4. Number of audits | 10. The amount of participation in health education | 16. Monthly use of fitness devices on the site |
| 5. Total number of training hours | 11. The amount of participation in health care programs | 17. The number of workers who are absent due to an accident in each shift |
| 6. The number of educational policies that have been implemented. | 12. The number of lost days in all departments around the world | 18. The number of workers who are absent due to exposure to toxic substances on each shift |
|                                |                                  | 19. Gaiter and safety showers per employee |
|                                |                                  | 20. The number of sick days in each department |
for the effectiveness of the performance measurement process [5, 46]. Therefore, regarding the steps taken in this study, the result-based and the process-based approaches were considered for selecting the indicators.

Results of Phase 2
Following the study framework for the selection of KPIs, a primary set of indicators, including 45 KPIs and 17 related educational ones, were collected. The results of the content validity assessment showed that among the 45 primary KPIs and 17 educational ones, 12 and 9 indicators had acceptable validity, respectively. A total of 21 KPIs were recommended by the expert team for the purpose of evaluating the performance of occupational health with regard to the study objective (Table 4).

Results of Phase 3
According to results of criteria prioritization, relevance and specificity with the weights of 0.36 and 0.23 were the first and second priorities, respectively, and achievability and measurability with the weight of 0.16 were the third. Being time-bound was ranked fourth. The results of prioritizing the indicators are presented in Table 4.

According to Table 4 and based on the obtained

| symbol | Indicators                                                                 | CVI | CVR | The final weight |
|--------|---------------------------------------------------------------------------|-----|-----|------------------|
| H11    | Number of internal audits (annually)                                      | 0.84| 0.63| 0.092            |
| H12    | Number of external audits (annually)                                      | 0.90| 0.63| 0.105            |
| H13    | The percentage of health corrective actions that have been reviewed and their effectiveness approved. | 0.87| 0.63| 0.140            |
| H14    | The percentage of corrective and preventive health measures that have been taken. | 0.90| 0.63| 0.146            |
| H15    | The number of occupational health risk assessments (e.g., COSHH assessment and other risk assessment) | 0.84| 0.81| 0.089            |
| H16    | Percentage of work stations with harmful chemical agents                   | 0.87| 0.63| 0.076            |
| H17    | Percentage of work stations with inappropriate thermal conditions         | 0.90| 0.63| 0.047            |
| H18    | Percent of workstations with inappropriate lighting                       | 0.84| 0.63| 0.047            |
| H19    | The prevalence of hearing loss in employees                               | 0.87| 0.81| 0.033            |
| H20    | Incidence of hearing loss in employees                                    | 0.84| 0.63| 0.057            |
| H11    | The number of employees with mental stress                                | 0.84| 0.63| 0.067            |
| H12    | The percentage of work stations with ergonomic risk factors (poor ergonomic conditions that are likely to cause musculoskeletal disorders) | 0.90| 0.63| 0.073            |
| E11    | educational investment (in occupational health) per company’s GDP         | 0.81| 0.90| 0.206            |
| E12*   | Man-Hour Training in newly hired employees.                              | 0.81| 0.84| 0.067            |
| E13    | percent of trained supervisors in the year                                 | 0.63| 0.84| 0.082            |
| E14    | percent of trained managers in the year                                    | 0.81| 0.87| 0.044            |
| E15    | percent of workers that trained in work and emergency procedures         | 0.81| 0.90| 0.112            |
| E16    | Number of occupational health training courses that contractors have held for workers. | 0.63| 0.84| 0.049            |
| E17    | percent of job training programs for workers that have been implemented.  | 0.81| 0.87| 0.215            |
| E18    | percent increase in training hours                                        | 0.81| 0.87| 0.155            |
| E19    | The number of e-learning programs that have been held.                   | 0.63| 0.84| 0.081            |

*: man-hour OHS training is equal to the total hours of training provided to each employee. H: health indicators, E: educational indicators, CVR: content validity ratio, CVI: content validity index.
weights, the percentage of corrective and preventive health actions with a weight of 0.146 was the first priority. The percentage of corrective health actions reviewed and their approved effectiveness had a weight of 0.140 and was in the second priority. The third and fourth priorities were, respectively, the number of external and internal annual auditing, with the weights of 0.105 and 0.092. Among the educational indicators, and based on the obtained weights, the percent of implemented job training programs for workers, 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.

**Discussion**

Forty-five health performance indicators were included in the first phase of this study. Once the content validity of the health performance indicators was assessed, 12 indicators with acceptable validity were selected. The selected indicators could provide positive or negative feedback on the effectiveness of corrective actions, corrective and preventive actions done after the auditing process, observation and assessment of the occupational health status, physical and chemical factors in the work environment, and other factors through periodic follow-ups. They could also be used to identify improvements needs, to set objectives, and to evaluate the intended interventions. Published reports showed that it is necessary to reduce the number of indicators and consider the key indicators. This was also considered in the present study, and only the key indicators were selected by an expert team in accordance with the existing situation in order to reflect the system conditions [47]. In this study, the selected indicators with SMART features could provide quantitative information on the state of occupational health management and reflect the state of the system. The proposed indicators in this study were based on the operational aspects of OHSMS. The operational aspects show the impact of the OHSMS on the work environment and the activities performed. In other words, they target the implementation of policies, rules, procedures, and guidelines [8, 48].

The indicators selected in this study were a combination of leading and lagging indicators. In other words, these indicators could be used to evaluate process-based and result-based performance. The effectiveness of ongoing efforts related to OHS could be assessed by monitoring the lagging indicators, and this is the reason why they are important [49]. They are also easy to gather, understandable and easy to use for benchmarking [50]. However, lagging indicators focus on failures and have limitations. They provide little information about the causes of the events, and if the system’s performance is weak, the causes cannot be identified [51]. Besides, the important condition for using them is the existence of an accurate reporting and recording system [52], and mere reliance on lagging health indicators represents a poor evaluation of health performance, because the absence of illnesses even after a few years does not guarantee an effective management of identified risks or absence of any occupational illnesses or complications in the future [16].

According to studies, the use of preventive tools, unlike lagging indicators, could provide the management with timely information on OHS status and predict potential OHS problems [53]. Instead of focusing on failures, leading indicators focus on safeguarding operations [54]. It has now been accepted that lagging indicators should complement leading ones, and a combination of these indicators can overcome the limitations of each [55]. The results of a study by Lindgard et al showed that a combination of leading and lagging indicators would provide more comprehensive data and make it possible to identify OHS issues that could not be detected by relying only on lagging indicators [56].

In a study aimed at indicating the application of the AHP method for selecting KPIs OHS through the use of SMART criteria, Podgórska initially prepared a set of 109 primary indicators, and then prioritized them using the AHP technique and SMART criteria. Finally, based on the results, 102 primary indicators were reduced to 20, amongst which 7 indicators were related to OHS education. In a study by Podgórska, the selected indicators were all leading performance indicators [12], while the use of any kind of indicators had been emphasized in other studies [46, 50, 56, 57]. In Podgórska’s study, the indicators were selected to be used in all industries, but in the present study,
the proposed indicators were of both leading and lagging types, selected and prioritized in a stepwise process according to the internal needs of the organization and its performance status. In the study by Podgórski, the indicators were quantitative, selected according to specific SMART criteria. This is consistent with the results of the present study [12].

The status of small and medium-sized industries was considered in a study by Tremblay and Badri, and a set of leading indicators was proposed for OHS performance evaluation based on a review of the studies and the judgment of experts. Using AHP, the performance indicators were prioritized, the result of which is in line with that of the present study. But in their study, Tremblay and Badri did not consider the SMART criteria and the selected indicators were only leading. In this regard, it is not consistent with the results of this study [58].

In this study, special emphasis was placed on related educational indicators in addition to operational performance indicators in the field of OHS-MS. Following the study framework, the researcher proposed 17 related educational indicators in the field of OHSMS, 12 of which had acceptable content validity and were selected for prioritization.

Various studies have considered training the personnel and head workers as a leading indicator [12, 32, 59–60]. OHS educational indicators have also been taken into consideration in several performance reports by a variety of car manufacturers (Table 3). Vredenburgh examined six occupational management actions in 62 hospitals in order to select the most effective measures to reduce the number of injuries, and the results showed that training and recruiting the staff with safe work records was the most effective action that hospital managers could do [59]. In the study by Pawłowska, the indicators used in 60 industries were examined and the results showed that leading indicators had been used mainly in high-performance companies. Besides leading indicators such as OHS training programs as well as risk assessment, the number of non-compliances, and the number of work stations that were better managed against risks had a strong and significant relationship with OHS performance. In the OHS Standard Guideline (Clauses 3-4 of ILO-OSH, Clauses 2-4-4 of OHSAS18001, and ISO 45001), the importance of training and determining the educational needs proportionate to risks has been pointed out [61–63].

Twenty-one indicators were proposed in this study. The results of prioritizing the indicators showed that among the health indicators, the percentage of corrective and preventive health measures with a weight of 0.146 was the first priority. The percent of corrective health measures examined and their effectiveness was the second priority, with a weight of 0.140, and the number of annual external and internal audits were the third and fourth, with the weights of 0.105 and 0.092, respectively. The results indicated that most of the leading indicators were in the top prioritized, and this is consistent with the results of Janackovic’s study [46]. The results of the prioritization of educational indicators also showed that the percentage of implemented training programs for workers was the first priority, with the weight of 0.215; educational investment per company’s GDP with a weight of 0.206 was second; and the percent of increased training hours as well as the percent of workers trained in emergency procedures, such as relief and rescue and first aid, were third and fourth priorities, with weights of 0.155 and 0.122, respectively. Promotion of individuals’ education to maintain health is one of the strategic goals of safety and health performance that should be achieved in line with the development and institutionalization of the OHS principles in organizations [64]. Recent studies have shown that OHS training is an important tool in preventing injuries, risks and occupational diseases [65–67] because it is a prerequisite for improving OHS [67].

Limitations of the study, recommendations for further research, and possibility of generalization in other industries

The results of the process of selecting key performance indicators should be reviewed and approved by more OHS experts. The selected indicators should also be tested in automotive companies already maintaining OSH-MS. Using only the AHP method when we have a lot of measurement indicators will increase the number of pair comparisons. In this study, 66 paired comparisons were conducted according to each criterion (330 pair comparisons) to prioritize health indica-
tors; 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). The results of this study can be used in automotive and other industries, but it is best to define performance indicators based on the strengths and weaknesses of the organization. The performance measurement indicators used in different companies vary because there are different weaknesses and opportunities for improvement in different companies.

Conclusion

A set of primary key indicators was proposed on the basis of the research objective, which would allow managers and industrial hygiene experts to select appropriate key indicators in order to assess the performance of the industrial hygiene unit based on the company’s status. A set of specific operational performance indicators was also obtained in a car manufacturing company to implement an effective performance evaluation system in order to achieve OHS goals and programs with effective activities.

Acknowledgements

We thank the Occupational Health Department and Research Deputy of Iran University of Medical Sciences. This article has been extracted from a master’s thesis. This research was supported by grant No. 2967, and Code of ethics (IR.IUMS.FMD.REC 1396.951139002) from the Iran University Medical Science.

Conflict of interest

The authors declare no conflict of interest.

Author’s contribution

The magnitude of each author’s contributions is reflected in the author order.

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労働衛生改善のための重要業績評価指標の特定、選択、優先順位付け：自動車メーカー1社を対象とした事例研究

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要　旨：組織の継続的な改善における労働衛生の重要な役割について、本研究は自動車メーカー1社を対象に、労働衛生改善にむけた重要業績評価指標の特定、選択、優先順位付けを目的とした。記述的横断研究を三段階で行った。まず半構造化インタビューとメーカーの文書および既存の研究の検証、見直しを行い、一連の重要指標を特定、選択した。次に指標の妥当性を11名の専門家が測定した。続いて、SMART基準をもとに指標に優先順位をつけた。研究枠組みにしたがい、45の健康指標と17の教育指標を含む一連の指標を集めた。内容的妥当性を調査した結果、それぞれ12および9の指標が妥当性を満たし、専門家チームによって本研究に対し全部で21の指標が提示された。優先順位付けの結果は、は正的、予防的健康行動が採られた割合といった先行指標が重み0.146で最優先であった。一連の重要指標は、本研究目的に基づく結果から提示されたもので、自動車産業において管理者や産業衛生の専門家が業績評価を行う際の一助となりうる。

キーワード：労働衛生、健康、特定、産業。

JUOEH（産業医大誌）42(1): 35 - 49 (2020)