Identification of key leading indicators for improving occupational health and safety systems in small and medium-sized cold storage facilities

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ABSTRACT

Manual handling employees who work in cold environments are at risk of cold-related disorders, decreased productivity, and safety issues. This paper proposes a hybrid method for selecting and ranking the key indicators of occupational safety in small and medium-sized cold storage facilities. The methodological approach begins by establishing a decision-making group composed of experts who assess risks in cold storage companies, in cooperation with occupational safety representatives from these organisations. The evaluation framework includes six groups and thirty-three indicators. The weights of the groups and indicators are determined through pairwise comparisons using triangular fuzzy numbers to incorporate uncertainty in the group decision-making process. The results indicate that adequate employee engagement and management commitment have a significant potential to improve occupational health and safety systems.

OPSOMMING

Werknemers wat handmatige hantering doen in koue omgewings loop die risiko van koue-verwante afwykings, verlaagde produktiwiteit en veiligheidskwessies. Hierdie studie stel 'n hibriedmetode voor om die sleutelaanwysers van beroepsveiligheid in klein en mediumgrootte koelopbergingsfasiliteite te selekteer en te rangskik. Die metodologiese benadering begin deur 'n besluitnemingsgroep te stig wat bestaan uit kundiges wat risiko's in koelbergingsmaatskappye beoordeel, in samewerking met beroepsveiligheidsverteenwoordigers van hierdie organisasies. Die evalueringsraamwerk sluit ses groepe en drie-en-dertig aanwysers in. Die gewigte van die groepe en aanwysers word bepaal deur paarsgewyse vergelykings met behulp van driehoekige newelversameling getalle om onsekerheid in die groep besluitnemingsproses in te sluit. Die resultate dui daarop dat voldoende werknemerbetrokkenheid en bestuursverbintenis 'n beduidende potensiaal het om beroepsgesondheid en veiligheidstelsels te verbeter.

1. INTRODUCTION

In many industries, employees perform daily work activities in cold and dry environments. These environments are often associated with cooler seasons or regions when outdoor work is considered. In addition, a significant number of employees spend at least part of their working time in indoor cold storage facilities. The food, retail food, healthcare, pharmaceutical, and technology industries rely on indoor refrigerators to store perishable goods, pharmaceutical products, and specialised equipment, such as batteries, at low temperatures. Maintaining a low temperature prevents the initiation of processes that lead to the deterioration of goods, preserving product safety and quality while ensuring compliance with applicable regulations. Consequently, there is a significant demand for cold storage solutions and specialised technologies to support these sectors.

The distribution of cold storage facilities varies by region and country. In areas with developed agriculture or industry, a significant number of cold storage facilities may exist to support the storage and preservation of perishable goods. In contrast, less developed regions often face limited access to cold storage infrastructure owing to factors such as insufficient investment or inadequate logistics. Employees working in cold environments such as indoor cold storage facilities are exposed to the health risks associated with prolonged exposure to low temperatures. This paper focuses particularly on small and medium-sized enterprises and smaller indoor cold storage facilities and on employees who are engaged in manual material handling.

Cold environments have numerous effects on both the success of work activities and the biological parameters of employees [1],[2],[3]. Long-term exposure to extreme temperatures can have severe physical and mental health consequences [4],[5],[6],[7]. Various authors have analysed the effects of extreme cold on different body parts, including the upper extremities [8], muscles [9], hands [10],[11], lung [12], skin [13], and neck and lower back [14]. Exposure to low temperatures triggers specific physiological responses, especially during sudden temperature changes, such as during entering and exiting cold storage areas [15],[16]. The growing demand for cold chains in various industries has increased the number of employees working in cold indoor environments, making it important to explore ways to improve working conditions [17], particularly by addressing thermal stress and its effects on employees' productivity and well-being [18],[19]. The effects of cold indoor environments have received less attention in research than those of hot environments. This research aims to emphasise the significance of assessing work procedures and the occupational risks encountered by employees in demanding working conditions.

The performance of a safety system plays a significant role in shaping an organisation's overall image. Industrial standards and recommendations emphasise the importance of safety performance management, as demonstrated by the ISO 45000 series. Specifically, ISO 45001 emphasises the critical role of safety performance management in maintaining and improving workplace safety.

Occupational safety performance is measured using indicators that describe the outcomes achieved in the safety system. These descriptive and numerical indicators facilitate the dynamics of monitoring workplace safety, and reflect changes resulting from efforts to reduce risks in the work environment. These efforts encompass not only procedures for risk management, but also other organisational activities that are aimed at the continual improvement of safety performance. There are numerous polemics and analyses of safety performance indicators. These indicators are typically classified into two categories: leading indicators and lagging indicators [20]. Traditionally, lagging indicators have been employed to assess the effectiveness of safety systems. These indicators, also referred to as outcome indicators, describe results based on past incidents, and present insights into the consequences of previous safety failures.

In contrast, leading indicators aim to encourage the prevention of possible incidents and the avoidance of adverse outcomes [21]. These indicators focus on events and actions that occur before accidents happen, and are proactive. Thus, they are often referred to as activity indicators. Their primary goal is to identify issues in the safety system or work environment before they grow into adverse events that could endanger employee safety and health.

A common difficulty in the broader application of leading indicators in practice involves misunderstandings about their adequacy, issues related to measurability, and the need for additional resources to monitor them. As a result, safety reporting often relies on lagging indicators such as the cost of injuries, the number of lost working days or hours, or the accident rate. While these indicators can prompt organisational actions if values exceed predefined thresholds or display negative trends, they are limited in identifying precursor conditions and events that lead to adverse outcomes. Leading indicators, in contrast, form the foundation for developing a proactive framework for hazard identification, systematic risk management, and the prevention of potential safety failures. They focus on the activities of organisational units and individuals, thus enabling a proactive approach to safety management. However, an excessive number of indicators can lead to unnecessary resource allocation and diminish the importance of certain key indicators. Multi-criteria analysis methods allow for the comparison and ranking of indicators, which helps to identify those with the greatest impact [20],[22]. To address uncertainty and to simplify the involvement of experts from various fields, linguistic variables and fuzzy numbers were employed in the analysis. A hierarchical classification of indicators enables the use of the analytical hierarchy process (AHP). In this analysis, triangular fuzzy numbers were applied within the fuzzy AHP framework.

2. MATERIALS AND METHOD

The aim of this study is to determine key leading indicators that can improve occupational safety systems, such as safety and health at work for employees in cold indoor environments. The study specifically emphasises smaller cold storage facilities, in which employees perform manual tasks such as material handling.

This research builds on previous results that have explored leading indicators in occupational safety both broadly [21] and in specific activities [20], [22]. The research process consists of the following stages: a) a preparatory stage for identifying the most important previously analysed safety indicators; b) expert group formation and conducting initial consultations about the identified leading indicators; c) identifying key indicators that enhance the safety system through experts' ranking; d) ranking of key indicators using group fuzzy AHP; and e) analysing the outcomes and incorporating the expert observations.

2.1. Preparation stage

When analysing the leading indicators, data from articles and journals primarily referenced in the Scopus and Web of Science (WoS) databases were used. The analysis was informed by the extensive scope and broad acceptance of these databases. In addition, data available through the Google Scholar service were used for initial searches. No specific time limits were set in order to gain insight into research trends over an extended period. The search, conducted in October 2024, was based on selected keywords and phrases ("safety", "leading indicator", "proactive indicator", and "activity indicator"). From the analysed articles, leading indicators were identified and classified into groups.

The proposed hierarchical structure is presented in Table 1. The classification has six groups: management commitment (*M*), workplace conditions monitoring and hazard identification (*H*), training and competence (*T*), engagement and participation (*P*), health and well-being (*L*), and process and system specificities (*S*).

2.2. Selection of experts

The expert group was formed primarily on the basis of the participants' expertise and experience. All the experts were required to meet a general prerequisite for their participation: an active role in the safety management system, or prior involvement in risk assessment activities in the companies performing the analysed activities. A minimum of five years of work experience in occupational safety and at least three years of experience specific to the activity and risk assessment were also prerequisites. Previous experience served as the basis for determining the weight coefficients (significance coefficients) of the individual experts during group decision-making (determination of weights and the ranking of indicators).

Let n be the number of indicators to be compared, and m the number of experts involved in the decision-making process. To account for the influence of the i-th expert, an experience coefficient ψ_i is introduced and determined for this purpose as follows:

$$\psi_i = \left(\alpha_i \cdot \beta_i \cdot \theta_i\right) \Big/ \sum_{j=1}^{m} \left(\alpha_j \cdot \beta_j \cdot \theta_j\right), \tag{1}$$

where i=1,...,m; α_i describes experience in risk assessment; β_i is work experience in risk assessment in cold storage facilities; and θ_i is the total work experience of the i-th expert. The scale for determining experience is as follows: a value of 1 describes experience of two to three years, a value of 2 represents experience of three to five years, and a value of 3 represents experience of more than five years. The set of values $\Psi=\{\psi_1,\psi_2,\ldots,\psi_m\}$ is the expert weight vector, where $\psi_i>0$, and $\sum_{i=1}^{m}\psi_i = 1$.

Table 1: Proposed classification of leading indicators

Group	Indicator	Reference
Management commitment (M)	Safety review meeting frequency (M_1) Resource allocation for safety programmes (M_2) Management response time to safety reports (M_3) Policy review and update frequency (M_4) External communication and information exchange in the communities of knowledge (M_5)	[20],[23],[24],[25],[26],[27]
Workplace conditions monitoring and hazard identification (H)	Workplace conditions monitoring (H_1) Housekeeping (H_2) Cold-stress safety checks (H_3) Risk assessment (hazard identification) frequency (H_4) Application of digital technologies (H_5)	[18],[28],[29],[30],[31],[32],[33]
Training and competence (T)	Safety training completion (T_1) Safety training quality (T_2) Safety training effectiveness and skills retention (T_3) Safety drill frequency and outcomes (T_4) Onboarding and orientation quality (T_5) Check of readiness before starting a work activity (T_6)	[23],[32],[33],[34],[35]
Engagement and participation (P)	Safety committee participation and frequency (P_1) Employee feedback on safety level (P_2) Frequency of management safety walk-throughs (P_3) Recognition of safety contribution (P_4) Safety training participation (retention) (P_5) Contractors' safety suggestions (involvement) (P_6)	[36],[37],[38],[39],[40]
Health and well-being (L)	Presenteeism and absenteeism rates (L_1) Employee health programme participation (L_2) Employee wellness programme participation (L_3) Ergonomic assessment participation (L_4) Mental health and burnout metrics (L_5)	[26],[41],[42],[43],[44],[46]
Process and system specificities (S)	Compliance with safety procedures (S_1) Work permits and authorisation compliance (S_2) Preventive workplace and equipment inspections (S_3) Frequency of internal safety audits and reviews (S_4) Frequency of external safety audits and reviews (S_5) Near-miss and incident reporting (S_6)	[20],[23],[25],[28],[45],[47]

2.3. Identification of key indicators

When considering leading indicators, the large number of groups and individual indicators requires that they be ranked. A higher number of indicators reduces their individual impact and increases the resources needed for monitoring. In addition, analysing and making decisions becomes more complex and prone to errors. Ranking helps to identify key indicators that require special attention. To address this, the identification was conducted in two steps. The first step involved selecting key indicators from each group, and the second step entailed ranking these selected key indicators.

The selection of key indicators was performed using the method of expert evaluations. This approach was chosen because the evaluation of the observed systems and their properties could not be fully achieved through objective measurements. Further, all the necessary initial information was not available. Using their high level of expertise as an in-depth understanding of system behaviour, the experts provided assessments of the system elements and of their impact on overall functionality. The results of the group assessment of the experts enabled a list of key indicators to be formed. The lowest rank (value 1) was assigned to the least significant indicator. Strict ranking was applied, meaning that the experts assigned unique ranks to each indicator without ties. When ranking, the sum of all assigned ranks was equal to the sum of the sequence of numbers from 1 to n, where n represented the total number of ranked indicators. To ensure the acceptability of the expert assessments, the agreement among the experts' opinions was analysed using the concordance coefficient:

$$W = \xi / \xi_m ,\tag{2}$$

where

$$\xi = \sum_{j=1}^{n} \sum_{i=1}^{m} \left(\rho_{ij} - (n+1) \cdot m/2 \right)^2 ,\tag{3}$$

and

$$\xi_m = n \cdot \left(n^2 - 1 \right) \cdot m^2 / 12 ,\tag{4}$$

where ρ_{ij} represents the rank assigned by i-th expert to the j-th indicator [48].

Bearing in mind that W=1 represented complete agreement (identical ranking of indicators), values of W greater than 0.5 generally confirmed a significant level of agreement among the experts' opinions. In this study, the acceptance level of W=0.6 was used.

2.4. Ranking of key indicators

For the purposes of ranking, the group fuzzy analytical hierarchy process (FAHP) was applied. The hierarchical structure presented in Figure 1 consisted of three levels: the root represented the goal, the middle level contained the criteria (groups of indicators), and the leaves corresponded to the leading indicators defined in Table 1.

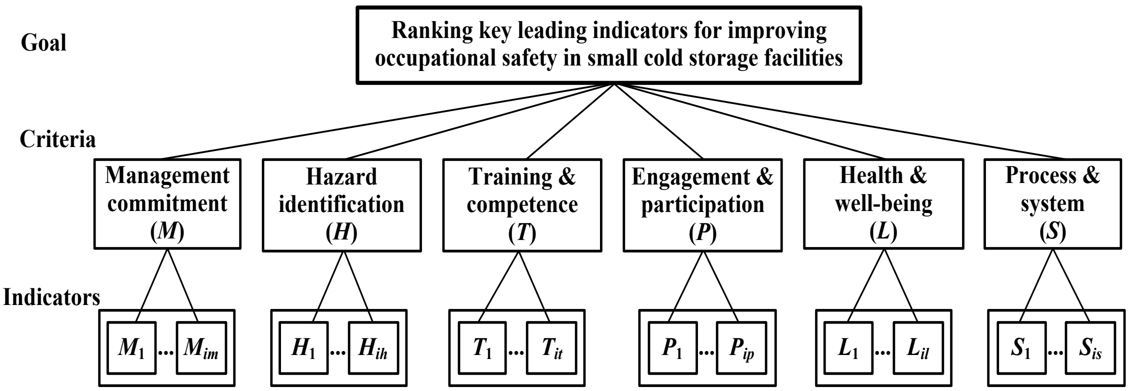

Figure 1: Hierarchical structure for ranking

The procedure for determining weights was as follows. Let $D^{(k)}$ represent the comparison matrix of the k-th expert, with ψ_k representing the experience coefficient of that expert. The total (aggregate) pairwise comparison matrix $D=[d_{ij}^{(k)}]_{nxn}$, where n is the number of indicators or groups of indicators being compared, consists of n^2 elements. These elements are calculated as the geometric mean of the values from the individual comparison matrices of the experts:

$$\tilde{d}_{ij} = \left(\prod_{k=1}^{m} \left(\tilde{d}_{ij}^{(k)} \right)^{\psi_k} \right)^{1/m} ,\tag{5}$$

where i,j=1,...,n; $d_{ij}^{(k)}$ is the rating provided by the k-th expert, and ψ_k is the expert's weight coefficient describing his or her experience.

During the pairwise comparisons, the experts used triangular fuzzy numbers (b-δ, b, b+δ), where δ was the fuzzy distance ranging from 0.5 and 2, and b was an integer within the range [1,9] (Figure 2, left). For this research's purposes, the following fuzzy numbers were used: δ=2 for odd b values (for example, (1,3,5)) and δ=1 for even b values (for example, (3,4,5)). The fuzzy value "1" was represented as (1,1,3), while the fuzzy value "9" was represented as (7,9,9). Symbolic representations of fuzzy numbers are "absolute" (A), "demonstrated" (D), "strong" (S), "weak dominance" (W), and "equal importance" (E). Intermediate values were denoted using combinations of the previously mentioned labels (Figure 2, right).

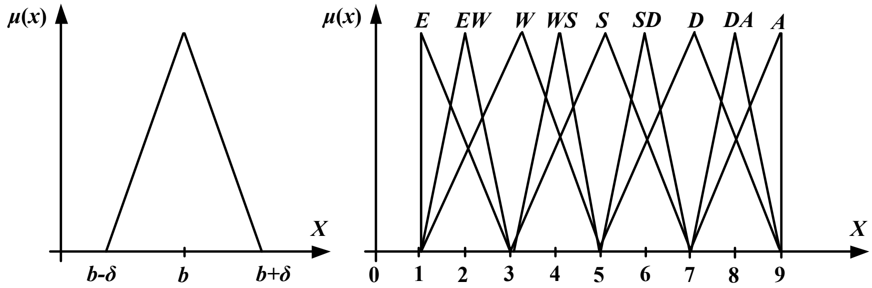

Figure 2: Membership function $\mu(x)$ (left) and fuzzy numbers (right)

Only consistent matrices were considered in the analysis. The consistency of individual comparison matrices was evaluated using the crisp values of the applied fuzzy numbers, and the λ_{max} value for each comparison matrix was calculated using the following approximate formula:

$$\lambda_{\max} = \sum \left(1/d_{ii}\right) \cdot w_j, \tag{6}$$

where i,j=1,...,n. Based on Eq. (6), the consistency index was obtained as $CI=(\lambda_{max}-n)/(n-1)$ and the consistency ratio as $CR=CI/RI$, for random index RI values corresponding to the dimensions of the pairwise comparison matrices n. The RI values used in the research were determined on the basis of our own calculations and of the results shown in [49]. For $3 \leq n \leq 10$ the RI values were {0.53,0.89,1.11,1.25,1.35,1.41,1.45,1.49}.

Matrices with a CI value exceeding 0.1 were returned to the experts for review and correction. Only consistent matrices were used to determine the aggregate matrix based on Eq. (4). When calculating the fuzzy aggregate matrix, an additional index was used to check the conformity of individual experts' evaluations, namely the centric consistency index (*CCI*) [50]. Acceptable values for matrices of certain dimensions are presented in [51]. Significant deviations in expert evaluations could have led to inappropriate results. This was mitigated through the careful selection of experts with extensive experience in the relevant field.

From the resulting aggregate matrix for n indicators, the fuzzy weight was obtained:

$$\tilde{w}_j = (w_{1j}, w_{2j}, w_{3j}) = \left(\prod_{l=1}^{n} \tilde{d}_{il}\right)^{1/n} \Big/ \left(\sum_{i=1}^{n} \left(\prod_{l=1}^{n} \tilde{d}_{il}\right)^{1/n}\right), \tag{7}$$

based on which crisp weight was determined as an arithmetic mean

$$w_j = \left(w_{1j} + w_{2j} + w_{3j}\right)/3, \tag{8}$$

and further, by means of normalisation,

$$MAW = w_j \Big/ \left(\sum_{k=1}^{n} w_k\right), \tag{9}$$

the mean aggregate weight (*MAW*) was obtained for the j-th indicator (j=1,...,n).

A higher crisp weight of an indicator in a certain group indicated its greater importance for improving the safety system compared with other indicators in that group. Similarly, a higher overall crisp weight of an indicator described its greater significance for enhancing the safety system relative to all other indicators.

3. RESULTS

The hybrid method of ranking occupational safety leading indicators was applied to identify key indicators for improving the safety system in small and medium-sized cold storages in the southeastern region of Serbia. A total of m=6 experts specialising in occupational health and safety participated, two of whom had extensive knowledge in ergonomics. The following sets represent the involved experts E_i and their experience: A={3,3,2,3,2,2}, B={2,1,2,1,2,2}, and Θ={3,3,2,3,3,3}. Using Eq. (1), the following weight set Ψ={0.26,0.13,0.12,0.13,0.18,0.18} was derived and applied when ranking the key indicators.

The initial thirty-three indicators were categorised into six groups. Based on Eqs. (2) to (4), the key indicators were determined (Table 2). The ranking was conducted using the average rank values, following the 'less is better' principle, as defined in Eq. (2). According to the expert evaluations, three key indicators (ranked 1 to 3) were selected from each of the six groups. The strongest consensus among the experts was observed for the groups 'Training and competence' (W_T=0.7873) and 'Process and system specificities' (W_S=0.7746), while the lowest was for the groups 'Workplace conditions monitoring and hazard identification' (W_H=0.6889) and 'Management commitment' (W_M=0.6806).

Table 2: Selection of key indicators

Group		E1	E2	E3	E4	E5	E6	ρ_{avg}	Rank	
Management commitment (M)	M1	3	4	5	5	5	5	4.50	5	
	M2	5	5	4	4	4	3	4.17	4	
	M3	2	3	1	2	1	4	2.17	2	
	M4	1	2	2	1	2	1	1.50	1	
	M5	4	1	3	3	2	2	2.50	3	W_M=0.6806
Workplace conditions monitoring and hazard identification (H)	H1	5	3	5	4	5	5	4.50	5	
	H2	3	4	4	1	3	4	3.17	3	
	H3	1	1	2	2	1	2	1.50	1	
	H4	2	2	1	3	2	1	1.83	2	
	H5	4	5	3	5	4	3	4.00	4	W_H=0.6889
Training and competence (T)	T1	4	6	6	5	6	6	5.50	6	
	T2	5	3	5	6	4	5	4.67	4	
	T3	2	1	3	3	2	3	2.33	2	
	T4	3	4	2	2	3	1	2.50	3	
	T5	6	5	4	4	5	4	4.67	4	
	T6	1	2	1	1	1	2	1.33	1	W_T=0.7873
Engagement and participation (P)	P1	5	4	4	6	3	5	4.50	4	
	P2	2	2	1	2	2	1	1.67	1	
	P3	1	3	3	1	4	4	2.67	3	
	P4	2	1	2	3	1	2	1.83	2	
	P5	6	5	6	5	6	3	5.17	6	
	P6	4	6	5	4	5	5	4.83	5	W_P=0.7079
Health and well-being (L)	L1	5	4	4	3	4	3	3.83	4	
	L2	3	2	1	4	3	4	2.83	3	
	L3	4	5	5	5	5	5	4.83	5	
	L4	1	1	2	2	1	2	1.59	1	
	L5	2	3	3	1	2	1	2.00	2	W_L=0.7333
Process and system specificities (S)	S1	1	2	1	3	3	2	2.00	2	
	S2	5	4	4	5	4	5	4.50	4	
	S3	3	5	6	6	6	4	5.00	5	
	S4	6	6	5	4	5	6	5.33	6	
	S5	4	3	3	2	1	3	2.67	3	
	S6	2	1	2	1	2	1	1.50	1	W_S=0.7746

A comparison of the factors (groups of indicators) is shown in Table 3. The aggregate matrix, which contains fuzzy numbers derived from the pairwise comparison matrices of the individual experts and calculated using Eq. (5), is also shown. The experts identified 'Management commitment' (w_M=0.23), 'Employee training and competence' (w_T=0.17), and 'Employee engagement and participation' (w_P=0.19) as the primary influencing factors of potential improvements to the occupational safety systems being considered. Although the differences in weight values were not large, the experts agreed that the fewest improvements would be expected in relation to hazard monitoring and identification (w_H=0.12) and process and system specificities (w_S=0.13).

Table 3: Comparison of factors (groups of indicators)

CCI=0.03	**M**	**H**	**T**	**P**	**L**	**S**
M	(1,1,1)	(1.21,2.02,3.73)	(0.71,1.16,2.09)	(0.64,0.97,2.16)	(0.67,1.37,2.49)	(1.07,2.32,3.30)
H	(0.27,0.50,0.82)	(1,1,1)	(0.36,0.67,1.01)	(0.34,0.63,1.15)	(0.49,0.70,1.33)	(0.82,1.49,2.47)
T	(0.48,0.86,1.41)	(0.99,1.48,2.81)	(1,1,1)	(0.44,0.92,1.40)	(0.59,1.15,1.76)	(0.54,1.22,1.86)
P	(0.46,1.03,1.56)	(0.87,1.57,2.94)	(0.72,1.09,2.28)	(1,1,1)	(0.68,1.27,2.17)	(0.71,1.32,2.14)
L	(0.40,0.73,1.50)	(0.75,1.43,2.04)	(0.57,0.87,1.70)	(0.46,0.79,1.47)	(1,1,1)	(0.63,0.88,1.88)
S	(0.30,0.43,0.94)	(0.40,0.67,1.21)	(0.54,0.82,1.85)	(0.47,0.76,1.40)	(0.53,1.13,1.60)	(1,1,1)
FWs	(0.09,0.23,0.60)	(0.05,0.13,0.32)	(0.06,0.18,0.43)	(0.07,0.19,0.50)	(0.06,0.15,0.41)	(0.05,0.12,0.34)
MAW	0.23	0.12	0.17	0.19	0.16	0.13

The aggregate matrices of the indicator comparisons, derived from the individual expert matrices and calculated using Eq. (5), are presented in Table 4. The *CCI* value was used to check the agreement level among the expert comparisons for each aggregate matrix. The FWs column contains the fuzzy weights obtained using Eq. (7), while the LWs column provides the local weights (crisp values) of the indicators derived from the fuzzy values in the FWs column using Eqs. (8) and (9).

Table 4: Comparison of indicators

CCI_M=0.01	M3	M4	M5	FWs	LWs
M3	(1,1,1)	(0.66,1.18,1.97)	(0.86,1.96,2.84)	(0.19,0.42,0.84)	0.40
M4	(0.51,0.85,1.52)	(1,1,1)	(0.94,1.69,2.81)	(0.17,0.36,0.77)	0.36
M5	(0.35,0.51,1.16)	(0.36,0.59,1.07)	(1,1,1)	(0.11,0.22,0.51)	0.23
CCI_H=0.02	H2	H3	H4	FWs	LWs
H2	(1,1,1)	(0.35,0.56,1.16)	(0.30,0.47,0.95)	(0.10,0.20,0.49)	0.22
H3	(0.86,1.79,2.84)	(1,1,1)	(0.76,1.28,2.28)	(0.19.0.42,0.88)	0.41
H4	(1.05,2.12,3.30)	(0.44,0.78,1.32)	(1,1,1)	(0.17,0.38,0.77)	0.37
CCI_T=0.02	T3	T4	T6	FWs	LWs
T3	(1,1,1)	(0.72,1.13,2.32)	(0.67,1.05,1.44)	(0.19,0.35,0.68)	0.36
T4	(0.43,0.88,1.38)	(1,1,1)	(0.78,1.29,1.96)	(0.17,0.35,0.64)	0.34
T6	(0.69,0.95,1.49)	(0.51,0.77,1.28)	(1,1,1)	(0.17,0.30,0.57)	0.30
CCI_P=0.01	P2	P3	P4	FWs	LWs
P2	(1,1,1)	(0.82,1.57,2.47)	(0.77,1.37,2.21)	(0.20,0.42,0.84)	0.41
P3	(0.40,0.64,1.21)	(1,1,1)	(0.49,1.19,1.54)	(0.13,0.30,0.58)	0.29
P4	(0.45,0.73,1.29)	(0.65,0.84,2.05)	(1,1,1)	(0.15,0.28,0.66)	0.31
CCI_L=0.01	L2	L4	L5	FWs	LWs
L2	(1,1,1)	(0.53,0.84,1.65)	(0.59,1.25,1.98)	(0.15,0.33,0.71)	0.33
L4	(0.61,1.19,1.90)	(1,1,1)	(1.03,1.66,2.88)	(0.19,0.41,0.84)	0.40
L5	(0.51,0.80,1.71)	(0.51,0.80,1.71)	(1,1,1)	(0.13,0.26,0.57)	0.26
CCI_S=0.01	S1	S5	S6	FWs	LWs
S1	(1,1,1)	(0.82,1.19,2.47)	(0.20,0.26,0.46)	(0.11,0.18,0.37)	0.20
S5	(0.40,0.84,1.21)	(1,1,1)	(0.16,0.23,0.33)	(0.08,0.15,0.26)	0.15
S6	(2.16,3.85,4.97)	(3.05,4.36,6.42)	(1,1,1)	(0.38,0.67,1.12)	0.65

Table 5 shows the ranking results for the key leading indicators. Column *w* contains the final crisp values of the indicator weights, while the preceding columns represent the LWs relative to their associated groups.

Table 5: Ranking key leading indicators

	Indicators	M 0.23	H 0.12	T 0.17	P 0.19	L 0.16	S 0.13	w	Rank
M3	Management response time to safety reports	0.40						0.092	1
M4	Policy review and update frequency	0.36						0.083	3
M5	External communication and information exchange	0.24						0.053	10
H2	Housekeeping		0.22					0.027	16
H3	Cold-stress safety checks		0.41					0.051	12
H4	Risk assessment (hazard identification) frequency		0.36					0.045	14
T3	Safety training effectiveness and skills retention			0.36				0.060	6
T4	Safety drill frequency and outcomes			0.34				0.057	8
T6	Check of readiness before starting a work activity			0.30				0.051	13
P2	Employee safety suggestions (involvement)				0.41			0.079	4
P3	Frequency of management safety walk-throughs				0.28			0.055	9
P4	Recognition of safety contribution				0.31			0.059	7
L2	Employee health programme participation					0.33		0.052	11
L4	Ergonomic assessment participation					0.40		0.063	5
L5	Mental health and burnout metrics					0.27		0.041	15
S1	Compliance with safety procedures						0.20	0.026	17
S5	Frequency of external safety audits and reviews						0.15	0.019	18
S6	Near-miss and incident reporting						0.65	0.085	2

4. DISCUSSION

From the analysis of the results obtained, the following may be concluded. The experts identified management commitment (w_M=0.23), employee training and competence (w_T=0.17), and engagement and participation (w_P=0.19) as the main factors influencing potential improvements. This emphasises the importance of both employee and management commitment and knowledge. The lower-ranked items are those that would likely lead to less significant improvements in the safety system or require substantial resources for implementation – resources that smaller organisations typically lack. The development of the monitoring system and good cooperation with external stakeholders in their maintenance suggest that only minor improvements may be expected from this factor.

Although there were no significant differences in the obtained weights, the *CCI* values suggested that there was consistency among the experts in ranking the key indicators for improving the safety system in the organisations considered. Among the key indicators, the most influential were those related to management response time (w_{M3}=0.092), near miss and incident reporting (w_{S6}=0.085), policy review and update frequency (w_{M4}=0.083), and employee feedback (w_{P2}=0.079). Other important indicators were ergonomic assessment participation (w_{L4}=0.063) and training effectiveness and skill retention (w_{T3}=0.060). Recognition of safety contributions (w_{P4}=0.059) and safety drills (w_{T4}=0.057) were also noted as having a significant impact.

Smaller organisations typically have simpler organisational structures, with much of the responsibility resting with management, which often holds both ownership and managerial roles. The commitment of management, their adequate understanding of safety, and their ability to respond quickly to deficiencies or risks in the safety system are crucial for the effectiveness and efficiency of the safety system. Owing to the limited resources, employee participation, knowledge, experience, and feedback become crucial for further improvements in the safety system. Employees are a valuable organisational asset, and their training, awareness of hazards in the work environment, and communication with management are fundamental to the continual enhancement of the safety system.

Smaller organisations often lack sufficient employees; those who are there tend to perform multiple tasks throughout the workday. Working in a cold indoor environment exposes employees to various hazards, ranging from physical to ergonomic risks. Sudden temperature changes when entering and exiting cold storage areas can cause immediate and intense physiological reactions, though such cases were not identified in the assessed organisational systems. It would be important to note that, while employees and managers are aware of the stress caused by sudden temperature changes, their potential long-term effects, whether physiological or behavioural, have not been given special consideration.

The limitations of this study lie primarily in the number of experts and organisations that were included, all of which were located in a small geographic region. Including a larger number of experts and organisational systems, particularly from regions with a higher turnover of goods (such as fruit-growing areas in southern or western Serbia), could help to determine whether the results from this analysis could be generalised.

5. CONCLUSION

Indicators are tools for measuring various effects in complex systems, such as occupational safety systems. To serve as a foundation for effective decision-making, they have to be sufficiently informative and unambiguous. While lagging indicators clearly demonstrate the outcomes of a safety system, leading indicators are valuable for their preventive nature, providing information to help avoid adverse consequences. According to the experts who were consulted in this study, the selected indicators are the basis for improving occupational safety systems.

The proper classification of leading indicators could help to create a better understanding of their impact on a company's performance and reputation. This study has presented a classification of leading indicators, organised into six groups containing 33 classified indicators. The list presented here is not exhaustive, and it could be expanded with additional indicators to adapt to internal organisational changes and external challenges in the business environment.

The variety of leading indicators could be difficult to apply in order to improve occupational safety systems in small and medium-sized enterprises. To address this, a hybrid approach was introduced to select and rank the key indicators. The hierarchical classification enabled the fuzzy AHP method to be applied. The hybrid method consisted of the experts' selection of key indicators and ranking, using the group fuzzy AHP method. Each expert's influence was determined on the basis of their previous experience, represented by a corresponding weight. Triangular fuzzy numbers were used to incorporate uncertainty into the decision-making process. Group ranking was applied to reduce subjectivity, allowing for consistency checks of the individual expert evaluations, and ensuring agreement among the experts in the group ranking.

Based on the results obtained here, improving the safety of manual handling workers in small and medium-sized cold storages could be achieved through adequate management activities, including shorter management response times to safety reports, more frequent safety policy updates, and better near-miss and incident reporting. Employee feedback would be important, supported by effective safety training and skills retention. In addition, taking into account manual handling activities, particular attention should be given to the ergonomic aspects, as working in cold environments creates additional problems.

Other methods of multi-criteria analysis that support group decision-making and that incorporate experts' weights could also be applied. In addition to triangular fuzzy numbers, other types of fuzzy numbers could be used to address uncertainty in the decision-making process. Further research will focus on exploring different scenarios for possible improvements in occupational safety systems, and developing a model to quantify the effects of changes on these systems.

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