



Ranking and Evaluation Risks of Human Error Factors in Uncertain and Imprecision Information

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Abstract

Reasons for Human Error, the term "risk" is used to describe the many potential causes of human mistakes. Capabilities, organizational culture, job complexity, and environmental variables are just a few of the many aspects that fall under this category. Accidents, improvements in safety, and gains in productivity may all benefit from a better understanding of and approach to minimizing human error. This paper highlights the necessity for comprehensive methods and actions to limit the effect of human error by providing an overview of the primary human error components and their implications for risk management. Due to various criteria, the concept of multi-criteria decision-making (MCDM) is used to deal with various criteria. This paper used the MCDM tools to rank and evaluate the risks of human error factors. The DEMATEL method is a MCDM tool is used to compute the weights of these factors and rank the risks. The DEMATEL method is integrated with the neutrosophic set to deal with uncertain information. This paper used the single-valued neutrosophic set with three values (truth, indeterminacy, and falsity) values. The twenty risks are identified in this paper and ranked.

Keywords: Uncertainty; Human Errors Factors (HEFs); Evaluation; MCDM; Neutrosophic Set.

1. Introduction

The risks connected with human error elements are a major obstacle in many different fields and companies. Accidents, injuries, monetary losses, and reputational harm are just some of the dire outcomes that may result from human mistakes. To improve safety results and build efficient risk management techniques, it is crucial to have a thorough understanding of the numerous elements that lead to human mistakes[1]–[4]. This study delves into the complicated interaction of individual traits, organizational variables, and environmental circumstances to uncover the causes of human mistakes and the accompanying hazards. Organizations may proactively reduce the effects of human mistakes and improve their overall safety and performance by conducting in-depth analyses of these risks and taking appropriate action to address them[5], [6].

Because of the gravity of the implications, human error is a major source of concern in sectors as diverse as the aviation, healthcare, manufacturing, transportation, and nuclear power industries. Understanding and managing human error elements is crucial because, despite technological and automation breakthroughs, people remain fundamental to many key operations. These elements include cognitive constraints of individuals, organizational culture, task complexity, and external variables. Errors may be reduced and positive safety results can be achieved if these issues are identified and addressed[7], [8].

A lack of proper education and experience is a major source of possible human mistakes. Errors are more likely to occur while executing complicated jobs or operating sophisticated equipment if the performer lacks the necessary

knowledge or abilities. Those who participate in training programs should graduate with the knowledge and skills required to perform their roles successfully. If this threat isn't mitigated, it may increase error rates and lower safety standards[9], [10].

A significant risk factor that contributes to human mistakes is tiredness and lack of sleep. Fatigue may decrease cognitive ability, concentration, and decision-making in occupations with long shifts, such as healthcare and transportation. Tired people are more likely to make mistakes, become less alert, and respond slowly. To reduce the likelihood of human mistakes caused by exhaustion, businesses should institute fatigue management measures such as shift rotation, rest periods, and education campaigns[11], [12].

Human performance may be hampered and mistakes made more often when attention is diverted or interrupted. People in the contemporary workplace are constantly bombarded with messages, requests for their attention, and other diversions. These interruptions might cause one to lose focus, redirect attention elsewhere, and make errors. Strategies to reduce distractions, such as quiet rooms, uninterrupted work time, and interruption management software, may assist reduce this threat[13], [14].

The dangers associated with human error elements are exacerbated by inadequate communication and information exchange. When there is a communication breakdown, inappropriate actions are taken, and safety is jeopardized. Errors may be minimized by prioritizing efficient communication channels, which include things like standardized documentation, explicit procedures, and frequent feedback systems. So, the concept of multi-criteria decision-making (MCDM) is used to deal with various error factors. The MCDM tools are used to analyze and rank the risks of HEFs. The DEMATEL method is an MCDM method used to compute the weights of these risks and rank them[15], [16].

Numerous applications exist for the decision-making trial and evaluation laboratory, including the resolution of multi-criteria decision-making issues in which linguistic variables are expressed as actual numbers. DEMATEL is an algorithm developed at the Battelle Memorial Institute in Geneva that uses matrices, codes, and digraphs to simplify the representation of otherwise intractable issues. By constructing causality diagrams, the DEMATEL method is utilized to establish a connection between the criteria. Therefore, it's better than MCDM in many ways. The connections and relative implications among the criteria are shown as digraphs. We may evaluate and enhance the criteria's cause-and-effect connection using this method[17], [18].

In general, the DEMATEL is used to establish a connection between different standards of assessment. It's a simple model that helps explain why there are so many moving parts in a choice. The DEMATEL technique classifies all assessment criteria into two categories: causes and their corresponding effects. numerous modern decision-making issues have effectively adopted the DEMATEL approach because of its numerous benefits. For each criterion pair, we use the DEMATEL process to evaluate them, and we base our evaluations on the actual numerical values assigned by five different judges of the same language. Di-graphs, as opposed to directionless graphs, are used in the causal diagram to depict the overarching idea of contextual interactions and the relative weights of the parts or criteria involved[19], [20].

Despite its many benefits, this method has numerous constraints when using linguistic values. Since the information provided is both hazy and partial, linguistic scales do not provide a more reliable result. This lack of detail means that the decision-maker's interpretations of the linguistic values may be flawed. It's possible for the method of making decisions to get complicated owing to misunderstandings of viewpoints or a lack of background information. Regarding such restrictions, the neutrosophic set theory was established. Single-valued neutrosophic sets are often used to represent solutions to real-time engineering challenges. To address issues in making decisions, several researchers have developed new applications for NSs. Their methods included the use of score functions, correlation approaches, and other measurements.

The main contributions of this study:

- A. This study is the first to use the neutrosophic set to deal with uncertain information in ranking the risks of HEFs.
- B. This study used large-scale data like using the 20 factors and many kinds of risks
- C. There are various experts and decision makers to evaluate the factors, so the difference between opinions is used in consideration in this paper.
- D. A single valued neutrosophic set was used for the first time in this kind of this problem.

2. Human Factors Errors in Medical Field

The healthcare system is seen as complex and high-risk because of the many processes, different types of equipment, and interconnected nature of its multiple parts. Medical mistakes are a major contributor to the high mortality and morbidity rates in this system. Makary and Daniel report that the number of Americans who lost their lives due to medical mistakes increased to 250,000, making it the third highest cause of mortality in the country. According to Khalil and Bates, adverse events occur after 1 in 10 hospital drug treatments. There has been a lot of focus on finding ways to decrease medical mistakes to improve patient safety. Recently, a large number of studies have pointed to human error as the primary cause of medical mistakes. As a result, a safer healthcare system may be established via the analysis of risk variables related to human error. Human error risk analysis in the healthcare system is complicated by two variables. On the one hand, the complex organizational structure of healthcare systems may increase the likelihood of human mistakes. As a result, determining the causes of human mistakes is very difficult. On the other hand, dormant human error factors might indirectly cause harmful occurrences by activating active human error factors. This makes it hard to model how they interact with one another[1], [2].

Several risk analysis methods for human error factors have been presented to address the aforementioned two challenging issues. HFACS (Human Factor Analysis and Classification System) has the advantage of taxonomy over other risk analysis techniques for human error factors like CREAM (Cognitive Reliability Error Analysis), SHERPA (Systematic Human Error Reduction and Prediction Approach), and HERA (Human Error and Recovery Assessment). Consequently, the HFACS has seen extensive implementation across the healthcare sector. This benefit allows it to determine the four-tiered causes of human mistakes, including risky behavior, inadequate training and supervision, and external impacts from the company. The HFACS, however, has several drawbacks that limit its usefulness. Here is a quick rundown of the most significant drawbacks. (i) The HFACS is inadequate as a qualitative analytic approach for conducting a quantitative study of the risk of human error components. The typical HFACS approach (ii) does not take into account the interdependent nature of the many elements that contribute to human error. (iii) The typical HFACS approach is inadequate to establish an accurate risk prioritization of these variables when considering the vast number of human error elements that already exist[12], [13].

3. Neutrosophic DEMATEL Methodology

New ideas have been offered and compared to existing SVN-DEMATEL processes. This approach, suggested by Boran et al., also takes into account the weight of the decision-maker. In this system, all decision-makers are given equivalent relative weights. Alternately, SVN-DEMATEL may be used to convert SVNN to real values. The suggested technique makes use of the average notion as an equation, which was presented by Radwan et al. The average of the three SVNS memberships yields an actual number. This approach rules out the possibility of incorrectly determining the multiplicative opposite of a matrix. This technique replaces the causal-effect diagram with the construction of four different sorts of criteria[21], [22]. To address the issue of coastal erosion, it is suggested that a hybrid decision-making trial and evaluation laboratory (DEMATEL) using single-valued neutrosophic sets be established. Figure 1 shows the steps of the proposed method.

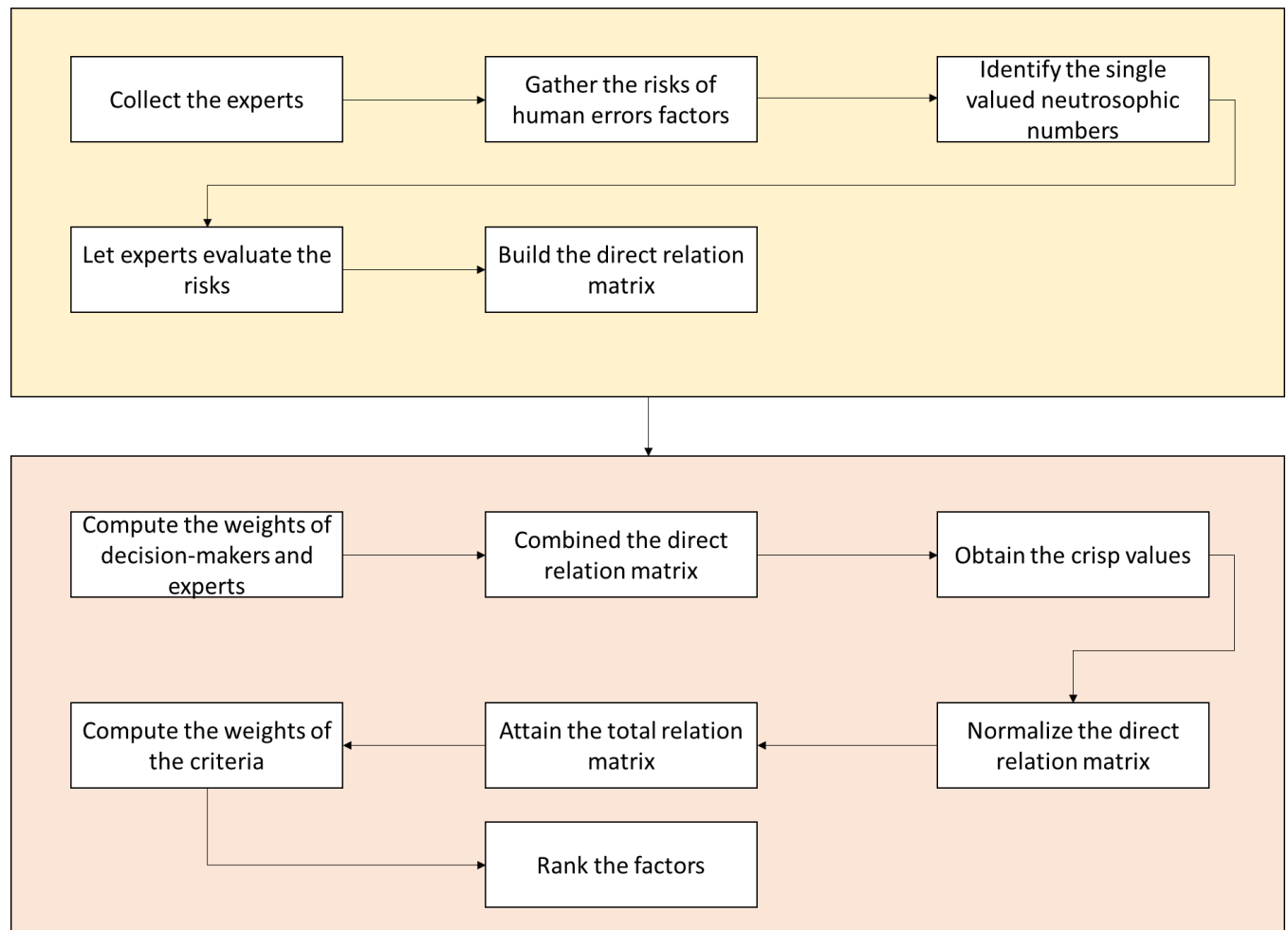


Figure 1: The Proposed framework to rank risks of human error factors.

3.1 Build the direct relation matrix

The direct relation matrix is built by using the opinions of experts in $n \times n$ matrix, where n refers to the factors. This paper used single-valued neutrosophic numbers to evaluate the factors.

3.2 Compute the weights of decision-makers and experts.

The single-valued neutrosophic set contains three values such as truth, indeterminacy, and falsity values (T, I, F) .

$$d_e = \frac{T_e(a)+I_e(a)(T_e(a)/I_e(a)+F_e(a))}{\sum T_e(a)+I_e(a)(T_e(a)/F_e(a)+F_e(a))} \quad (1)$$

3.3 Combined the direct relation matrix

The direct relation matrix is aggregated to compute one matrix.

$$CR_{ij} = [1 - \prod_{k=1}^e (1 - T_e(a))^{w_j}, \prod_{k=1}^e (I_e(a))^{w_j}, \prod_{k=1}^e (F_e(a))^{w_j}] \quad (2)$$

3.4 Obtain the crisp values

Convert the single-valued neutrosophic numbers into a crisp number as:

$$S(a) = \frac{1+T_e(a)+I_e(a)-2*F_e(a)}{2} \quad (3)$$

3.5 Normalize the direct relation matrix

$$N = d \times B \tag{4}$$

$$d = \min \left(\frac{1}{\max \sum_{j=1}^n |CR_{ij}|_{1 \leq i \leq n}}, \frac{1}{\max \sum_{i=1}^n |CR_{ij}|_{1 \leq i \leq n}} \right) \tag{5}$$

3.6 Attain the total relation matrix

$$T = N(I - N)^{-1} \tag{6}$$

3.7 Compute the weights of the criteria

$$w_j = \frac{w_j}{\sum_{j=1}^n w_j} \tag{7}$$

3.8 Rank the factors

4. Results

This section uses the neutrosophic DEMATEL method to analyze and rank the risks of HEFs. There are various risks of HEFs. This study used twenty risks for the evaluation process. Figure 2 shows the 20 risks of HEFs.

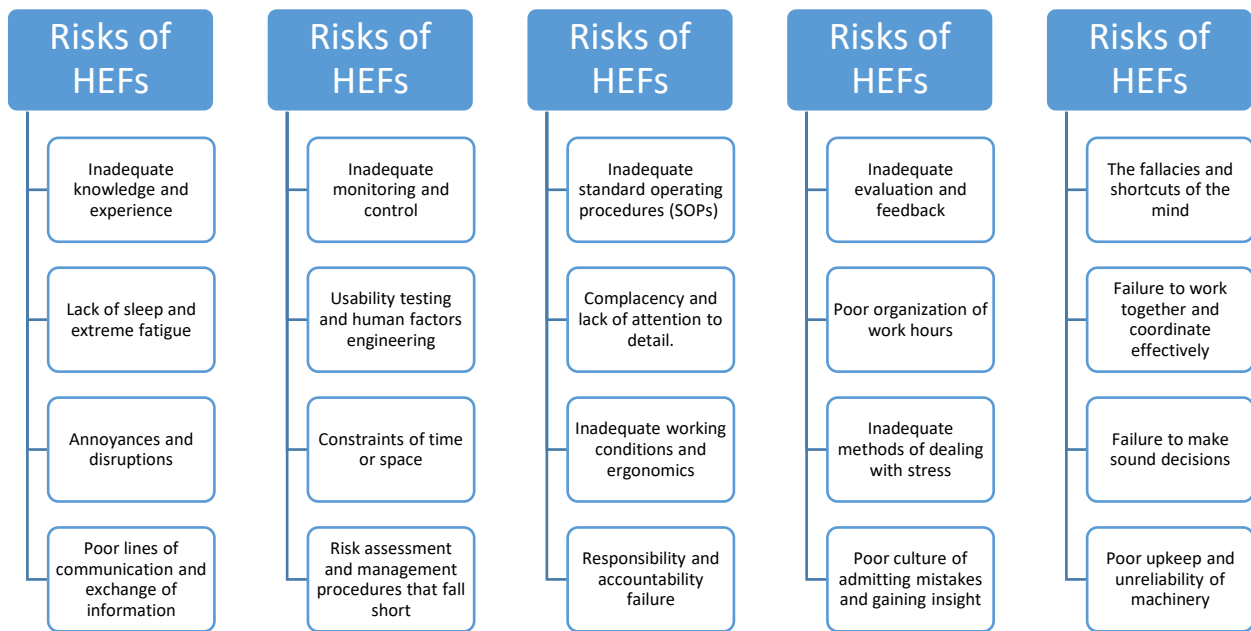


Figure 2: The 20 risks of HEFs.

Risks and possible vulnerabilities may be introduced into new areas through human error elements. Examples of human mistakes that are somewhat prevalent include the following:

Errors and blunders may occur as a result of inadequate or insufficient training. Inadequate training on tasks, methods, or equipment operation might leave workers without the competence to do their jobs safely and efficiently.

Fatigue and Stress: Excessive stress and fatigue may harm one's ability to think clearly and make sound decisions. Concentration, attentiveness, and judgment may all be impaired by lack of sleep, long work hours, or stressful conditions.

Interruptions, background noise, and conflicting demands all contribute to an office atmosphere that is less than conducive to focused work. Unfocused workers are more likely to make mistakes or miss important details.

Failures in communication may result in misinterpretations, mistakes, and threats to safety. Ineffective teamwork and higher error rates might result from a lack of communication, ambiguous instructions, or inadequate feedback systems.

Overconfidence or complacency may lead to a loss of awareness of details and a decrease in alertness. When people believe they have mastered a job or process, they are more likely to make mistakes or fail to see dangers.

A lack of clear and thorough standard operating procedures (SOPs) might increase the likelihood of making mistakes. Mistakes are more likely to occur when instructions are vague, out of current, or otherwise difficult to find and use.

Poor Ergonomics and Work Environment: Physical strain, lower productivity, and mistakes may result from the use of poorly designed or uncomfortable workstations, equipment, or tools. Poor lighting, uncomfortable sitting, or awkward body postures may all harm productivity and focus.

Individuals may be more prone to make mistakes when they do not feel responsible for their activities or when there is a general lack of accountability in the workplace. Without a shared sense of responsibility and ownership, it might be difficult to pay close enough attention to detail or follow established safety procedures.

Weak Management: When there isn't enough management in place, mistakes may pile up without being caught or corrected. A reduction in performance and an increase in the likelihood of making errors might result from a lack of feedback, coaching, or monitoring.

Errors are more likely to occur when a system, interface, or piece of equipment is poorly designed (human factors in design). User interfaces that are difficult to use, provide inadequate feedback, or have unclear controls are all potential causes of accidental events.

These sources of human error must be identified and ranked. So, we used the neutrosophic DEMATEL method to rank these risks.

Table 1: The direct relation matrices.

	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs	H E Fs
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	S2
H	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E		23	36	52	16	25	23	78	25	39	15	23	89	23	23	23	45	25	25	2
F				6		9	6	9	9		6	6	6	69	3	6	1	6	6	3
s1																				6
H	4.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	34		36	25	36	25	36	25	23	25	36	25	23	36	25	23	23	23	25	3
F	78		9	6	9	6	9	3	69	6	9	6	6	9	6	6	6	6	6	6
s2	26																			2
H	2.	2.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	77	71		39	26	24	23	23	25	23	23	23	23	23	25	23	23	36	85	2
F	77	00		2	3		6	69	4	6	6	85	69	6	63	6	6		9	5
s3	78	27																		6

H	1.	3.	2.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
E	90	90	55		52	36	52	23	36	63	32	36	23	36	52	23	36	23	96	1
F	11	62	10		6	8	6	9	9	9	6		6	9	6	6	9	6	2	2
s₄	41	5	2																	3
H	6.	2.	3.	1.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	25	71	80	90		36	26	36	36	25	36	95	69	45	89	26	23	23	78	2
F		00	22	11		9	3	9	9	3	9	62		62	2		6		9	5
s₅		27	81	41																6
H	3.	3.	4.	2.	2.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	86	90	16	71	71		25	36	25	69	52	25	36	36	26	26	24	36	48	8
F	10	62	66	73	00		63	9	6	5	6	6	9	9	3	3	66	9	9	5
s₆	04	5	67	91	27															6
H	4.	2.	4.	1.	3.	3.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	23	71	23	90	80	90		36	36	23	25	36	25	36	25	15	23	21	45	2
F	72	00	72	11	22	16		2	9	6	6	5	6	9	6	6	6	3	62	5
s₇	88	27	88	41	81	78														6
H	1.	3.	4.	4.	2.	2.	2.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	26	95	22	18	71	71	76		98	56	25	23	23	69	36	23	25	23	15	2
F	74	25	11	41	00	00	24		6	2	6	6	6	8	5	6	4	6	6	6
s₈	27	69	9		27	27	31													3
H	3.	4.	3.	2.	2.	3.	2.	1.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	86	22	93	71	71	90	71	01		85	56	36	25	56	45	23	23	21	25	2
F	10	11	70	00	00	62	00	41		9	3	9	6	3	63	6	6	3	6	3
s₉	04	9	08	27	27	5	27	99												6
H	2.	3.	4.	1.	3.	1.	4.	1.	1.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	56	90	23	56	95	43	23	77	16		23	23	23	95	78	25	23	23	78	2
F	41	62	72	49	25	88	72	93	41		6	6	6	6	9	4	6	6	9	5
s₁₀	03	5	88	45	69	49	88	59	44											9
H	6.	2.	4.	3.	2.	1.	3.	3.	1.	4.	1	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	41	71	23	06	71	90	90	90	77	23		96	96	36	65	23	25	23	96	4
F	02	00	72	74	00	11	62	62	61	72		3	3	9	9	6	6	6	32	5
s₁₁	56	27	88	85	27	41	5	5	99	88										6
H	4.	3.	4.	2.	1.	3.	2.	4.	2.	4.	1.	1	0.	0.	0.	0.	0.	0.	0.	0.
E	23	90	19	77	04	90	73	23	71	23	03		36	25	68	89	21	23	52	2
F	72	62	28	77	58	62	97	72	00	72	84		2	6	9	6	5	6	6	3
s₁₂	88	5	72	78	06	5	26	88	27	88	22									6
H	1.	4.	4.	4.	1.	2.	3.	4.	3.	4.	1.	2.	1	0.	0.	0.	0.	0.	0.	0.
E	11	23	22	23	44	71	90	23	90	23	03	76		25	65	78	36	12	23	2
F	60	72	11	72	92	00	62	72	62	72	84	24		6	89	9	9	3	6	5
s₁₃	71	88	9	88	75	27	5	88	5	88	22	31								6
H	4.	2.	4.	2.	2.	2.	2.	1.	1.	1.	2.	3.	3.	1	0.	0.	0.	0.	0.	0.
E	22	71	23	71	19	71	71	43	77	04	71	90	90		23	56	25	52	36	2
F	11	00	72	00	20	00	00	26	61	60	00	62	62		6	9	9	6	9	3
s₁₄	9	27	88	27	21	27	27	65	99	25	27	5	5							6
H	4.	3.	3.	1.	1.	3.	3.	2.	2.	1.	1.	1.	1.	4.	1	0.	0.	0.	0.	0.
E	29	90	90	90	12	80	90	73	19	26	51	45	51	23		45	25	52	23	2
F	18	62	16	11	10	22	62	97	15	74	74	13	76	72		6	6	6	69	3
s₁₅	45	5	78	41	76	81	5	26	41	27	51	79	81	88						5

H	4.	4.	4.	4.	3.	3.	6.	4.	4.	3.	4.	1.	1.	1.	2.	1	0.	0.	0.	0.
E	23	23	23	23	84	80	41	23	23	93	23	11	26	75	19		23	23	23	2
F	72	72	72	72	61	22	02	72	72	70	72	60	74	74	29		6	6	6	3
s₁	88	88	88	88	54	81	56	88	88	08	88	71	27	69	82					6
6																				
H	2.	4.	4.	2.	4.	4.	4.	3.	4.	4.	3.	4.	2.	3.	3.	4.	1	0.	0.	0.
E	21	23	23	71	23	05	23	93	23	23	90	65	71	86	90	23		23	25	2
F	72	72	72	00	72	51	72	70	72	72	62	11	00	10	62	72		6	63	3
s₁	95	88	88	27	88	5	88	08	88	88	5	63	27	04	5	88				6
7																				
H	3.	4.	2.	4.	4.	2.	4.	4.	4.	4.	4.	4.	8.	1.	1.	4.	4.	1	0.	0.
E	90	23	77	23	34	71	69	23	69	23	23	23	13	90	90	23	23		23	2
F	62	72	77	72	78	00	48	72	48	72	72	72	00	11	11	72	72		69	4
s₁	5	88	78	88	26	27	36	88	36	88	88	88	81	41	41	88	88			5
8																				6
H	3.	3.	1.	1.	1.	2.	2.	6.	3.	1.	1.	1.	4.	2.	4.	4.	3.	4.	1	0.
E	90	90	16	03	26	04	19	41	90	26	03	90	23	71	22	23	90	22		9
F	62	62	41	95	74	49	20	02	62	74	82	11	72	00	11	72	16	11		6
s₁	5	5	44	01	27	9	21	56	5	27	06	41	88	27	9	88	78	9		3
9																				
H	4.	2.	3.	8.	3.	1.	3.	3.	4.	3.	2.	4.	3.	4.	4.	4.	4.	4.	1.	1
E	23	76	90	13	90	16	90	80	23	86	19	23	90	23	25	23	23	07	03	
F	72	24	62	00	62	82	62	22	72	10	20	72	62	72	53	72	72	16	84	
s₂	88	31	5	81	5	24	5	81	88	04	21	88	5	88	19	88	88	61	22	
0																				

4.1 Build the direct relation matrix

This paper chose three experts and decision-makers who have expertise in risk assessment, decision-making, and human errors to evaluate these factors. So, we obtained three decision matrices. We used the single-valued neutrosophic numbers to evaluate these factors.

4.2 Compute the weights of decision-makers and experts.

We used Eq. (1) to compute the weights of decision-makers. The weights of the three decision-makers are equal.

4.3 Combined the direct relation matrix

The direct relation matrix is aggregated using Eq. (2), to compute one decision matrix as shown in Table 1.

4.4 Obtain the crisp value

We used Eq. (3) to compute the crisp value instead of three values of single-valued neutrosophic numbers.

4.5 Normalize the direct relation matrix

We normalized the direct relation matrix using Eqs. (3 and 4) as shown in Table 2.

Table 2: The normalized direct relation matrices.

	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	13	03	04	07	02	03	03	10	03	05	02	03	12	03	03	03	06	03	03	03
s₁	78	17	96	25	21	57	25	88	57	38	15	25	35	27	21	25	22	53	53	25

H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	59	13	05	03	05	03	05	03	03	03	05	03	03	05	03	03	03	03	04
s₂	93	78	09	53	09	53	09	49	27	53	09	53	25	09	53	25	25	53	99
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	38	37	13	05	03	03	03	03	03	03	03	03	03	03	03	03	04	11	03
s₃	29	35	78	4	63	31	25	27	5	25	25	29	27	25	53	25	25	96	84
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	26	53	35	13	07	05	07	03	05	08	04	04	03	05	07	03	05	03	13
s₄	21	84	16	78	25	07	25	29	09	81	49	96	25	09	25	25	09	25	26
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	86	37	52	26	13	05	03	05	05	03	05	13	09	06	12	03	03	03	10
s₅	15	35	41	21	78	09	63	09	09	49	09	18	51	29	3	58	25	17	88
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	53	53	57	37	37	13	03	05	03	09	07	03	05	05	03	03	03	05	06
s₆	22	84	43	46	35	78	53	09	53	58	25	53	09	09	63	63	4	09	74
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	58	37	58	26	52	53	13	04	05	03	03	05	03	05	03	02	03	02	06
s₇	41	35	41	21	41	78	78	99	09	25	53	03	53	09	53	15	25	94	29
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	17	54	58	57	37	37	38	13	13	07	03	03	03	09	05	03	03	03	02
s₈	47	48	18	67	35	35	08	78	59	75	53	25	25	62	03	25	5	25	15
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	53	58	54	37	37	53	37	13	13	11	07	05	03	07	06	03	03	02	03
s₉	22	18	27	35	35	84	35	98	78	84	76	09	53	76	29	25	25	94	53
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	35	53	58	21	54	19	58	24	16	13	03	03	03	13	10	03	03	03	10
s₁	34	84	41	57	48	83	41	53	05	78	25	25	25	18	88	5	25	25	88
0																			
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	88	37	58	42	37	26	53	53	24	58	13	13	13	05	09	03	03	03	13
s₁	36	35	41	28	35	21	84	84	48	41	78	27	27	09	08	25	53	25	28
1																			
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	58	53	57	38	14	53	37	58	37	58	14	13	04	03	09	12	02	03	07
s₁	41	84	79	29	42	84	76	41	35	41	31	78	99	53	5	35	96	25	25
2																			
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	15	58	58	58	19	37	53	58	53	58	14	38	13	03	09	10	05	01	03
s₁	38	41	18	41	98	35	84	41	84	41	31	08	78	53	08	88	09	7	25
3																			
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	58	37	58	37	30	37	37	19	24	14	37	53	53	13	03	07	03	07	05
	18	35	41	35	21	35	35	75	48	42	35	84	84	78	25	84	57	25	09

s1																			
4	H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	F	59	53	53	26	15	52	53	37	30	17	20	20	20	58	13	06	03	07
	s1	16	84	78	21	45	41	84	76	21	47	92	01	92	41	78	29	53	25
5																			
	H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	F	58	58	58	58	53	52	88	58	58	54	58	15	17	24	30	13	03	03
	s1	41	41	41	41	02	41	36	41	41	27	41	38	47	22	23	78	25	25
6																			
	H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	F	30	58	58	37	58	55	58	54	58	58	53	64	37	53	53	58	13	03
	s1	56	41	41	35	41	9	41	27	41	41	84	11	35	22	84	41	78	25
7																			
	H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	E	00	00	00	00	00	00	00	00	00	00	00	01	00	00	00	00	00	00
	F	53	58	38	58	59	37	64	58	64	58	58	12	26	26	58	58	13	03
	s1	84	41	29	41	93	35	71	41	71	41	41	06	21	21	41	41	78	27
8																			
	H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	F	53	53	16	14	17	28	30	88	53	17	14	26	58	37	58	58	53	13
	s1	84	84	05	33	47	19	21	36	84	47	31	21	41	35	18	41	78	18
9																			
	H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	E	00	00	00	01	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	F	58	38	53	12	53	16	53	52	58	53	30	58	53	58	58	58	56	14
	s2	41	08	84	06	84	1	84	41	41	22	21	41	84	41	66	41	41	12
0																			

4.6 Attain the total relation matrix

We obtained the total relation matrix by using Eq. (6) as shown in Table 3.

Table 3. The total relation matrices.

	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	
	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	
	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	Fs	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
F	14	03	05	07	02	03	03	11	03	05	02	03	12	03	03	03	06	03	03	
s1	19	64	42	62	5	87	61	19	84	64	31	45	54	42	36	4	32	61	6	
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
F	60	14	05	03	05	03	05	03	03	03	05	03	03	05	03	03	03	03	03	
s2	49	18	5	87	35	79	39	8	5	77	25	72	5	25	68	4	39	36	61	
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
F	38	37	14	05	03	03	03	03	03	03	03	03	03	03	03	03	03	05	11	
s3	99	84	19	73	9	58	57	63	78	5	43	49	55	45	73	45	43	11	94	

H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
F	27	54	35	14	07	05	07	03	05	09	04	05	03	05	07	03	05	03	13	01
s₄	24	6	77	18	62	45	67	72	41	1	71	21	55	34	49	47	27	42	42	8
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	87	38	53	26	14	05	04	05	05	03	05	13	09	06	12	03	03	03	11	03
s₅	39	34	22	78	19	56	14	66	51	92	35	5	91	59	58	84	49	38	1	66
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	54	54	58	38	37	14	04	05	03	1	07	03	05	05	03	03	03	05	07	11
s₆	76	98	41	15	88	19	05	58	94		54	89	5	4	96	91	67	32	02	95
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	60	38	59	26	53	54	14	05	05	03	03	05	03	05	03	02	03	03	06	03
s₇	12	63	59	96	03	25	19	41	42	61	79	35	89	35	82	38	47	14	57	71
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	19	56	59	58	38	38	38	14	13	08	03	03	03	09	05	03	03	03	02	03
s₈	33	01	59	52	15	03	63	18	95	12	83	59	58	92	32	47	7	44	46	8
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	55	59	55	38	38	54	37	14	14	12	08	05	03	08	06	03	03	03	03	03
s₉	24	75	77	29	24	57	97	48	18	27	07	43	91	09	59	49	48	14	85	46
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	37	55	59	22	55	20	59	25	16	14	03	03	03	13	11	03	03	03	11	03
s₁₀	47	43	99	54	44	73	13	09	51	18	59	67	7	57	24	78	51	5	19	76
0																				
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	90	39	60	43	38	27	55	54	25	59	14	13	13	05	09	03	03	03	13	06
s₁₁	79	61	63	73	77	44	12	81	22	13	18	76	82	6	58	63	89	58	7	54
1																				
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	60	56	60	39	15	55	39	59	38	59	14	14	05	04	09	12	03	03	07	03
s₁₂	8	14	01	75	88	09	08	3	05	12	74	18	44	02	93	67	26	52	64	51
2																				
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	18	61	60	60	21	38	55	59	54	59	14	38	14	04	09	11	05	01	03	03
s₁₃	08	06	77	06	59	91	36	44	67	31	79	55	19	04	55	21	36	95	69	78
3																				
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	60	39	60	38	31	38	38	21	25	15	37	54	54	14	03	08	03	07	05	03
s₁₄	76	67	73	98	47	74	74	08	5	67	92	55	45	18	71	25	88	51	5	5
4																				
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	61	56	56	27	16	53	55	38	31	18	21	20	21	58	14	06	03	07	03	03
s₁₅	82	1	14	8	89	86	17	77	05	34	56	78	7	92	18	65	83	53	64	5
5																				
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

F	62	61	61	60	55	54	90	59	59	55	59	16	18	24	30	14	03	03	03	03
s₁	3	71	89	62	18	44	35	8	47	47	11	14	21	97	83	18	61	59	83	6
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	35	62	62	40	60	58	61	56	60	60	55	65	38	54	54	59	14	03	04	03
s₁	18	48	71	23	96	62	33	48	2	35	1	33	43	31	73	04	19	65	15	64
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	01	00	00	00	00	00	00	00
F	58	63	43	61	62	40	68	61	67	61	59	60	13	27	27	59	58	14	03	03
s₁	49	04	1	83	88	47	2	24	11	05	93	08	36	41	4	41	97	19	92	79
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	57	57	19	17	20	30	33	90	56	19	15	27	60	38	59	59	54	58	14	13
s₁	41	57	76	35	02	93	34	83	11	6	96	9	18	78	37	62	61	7	19	61
H	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
E	00	00	00	01	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	63	42	58	15	56	19	57	55	61	55	32	60	55	60	60	59	59	56	15	14
s₂	25	97	66	51	87	31	47	32	8	09	4	86	02	08	76	34	74	03	19	0

4.7 Compute the weights of the criteria

We compute the weights of risks of HEFs by using Eq. (7) as shown in Table 4.

4.8 Rank the factors

Then rank these risks by the largest value in weights. Risk 20 is the highest weight and risk 1 is the lowest weight.

Table 4: The weights of criteria.

Factors	Weights	Rank
HEFs ₁	0.010282	20
HEFs ₂	0.014425	19
HEFs ₃	0.015776	18
HEFs ₄	0.021606	17
HEFs ₅	0.030621	16
HEFs ₆	0.032736	15
HEFs ₇	0.034909	14
HEFs ₈	0.037312	13
HEFs ₉	0.041416	11
HEFs ₁₀	0.041199	12
HEFs ₁₁	0.05617	7
HEFs ₁₂	0.054113	10
HEFs ₁₃	0.057404	6
HEFs ₁₄	0.054366	9
HEFs ₁₅	0.055662	8
HEFs ₁₆	0.076942	5
HEFs ₁₇	0.087702	3
HEFs ₁₈	0.097786	2
HEFs ₁₉	0.077569	4
HEFs ₂₀	0.102003	1

5. Conclusions

Overall, the stakes associated with human error elements are high enough to pose serious problems for businesses in a wide range of sectors. Because of the complex nature of the risks involved, organizations may improve safety results by using specific risk management practices. Individual training and competence, managing weariness and distractions, enhancing communication and information sharing, and developing a culture of continuous improvement and attention to detail are all necessary to effectively mitigate these risks. Organizations may reduce the effects of human error and improve the safety and dependability of their operations by investing in risk management strategies. So this paper used the single-valued neutrosophic DEMATEL method to show the weights of each factor and rank it. The single valued neutrosophic set is used to overcome the impression and vague information. The DEMATEL method is an MCDM method that can deal with various factors, so we collected 20 factors to rank and evaluated. Factor 20 is the highest weight and Factor 1 is the lowest weight.

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