The Use of Multi-Criteria Decision-Making Methods to Support Risk Prioritisation

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Abstract

The risk evaluation process assists decision-making concerning the prioritisation of risks. In practice, risk prioritisation decisions highly rely on the estimation of risk scores. Risk scoring is a semi-quantitative approach to analyse risks. Often, a score from 1 to 5 is assigned for the likelihood and consequence of the risk. Consequently, a risk score from 1 to 25 is calculated by multiplying two scores. However, the sole use of risk scoring might not be useful to prioritise risks. Multiple factors should be considered to make prioritisation decisions. At this instant, Multi-Criteria Decision-Making (MCDM) methods have been widely used by researchers to prioritise alternatives by given conflicting criteria. This study used expert judgement, MCDM methods and Risk Priority Number (RPN) to prioritise ten actions recommended for the treatment of five risks. The findings provided different ranking orders for the prioritisation of the recommended actions, except for the first one. This study discusses the potential benefits and limitations of the use of expert judgement, MCDM methods and RPN in risk prioritisation.

Keywords
Risk prioritisation, Decision-making, Safety management.

1. Introduction

Risk evaluation assists decision-making regarding the prioritisation of risk treatment actions (BSI 2009). In so doing, the level of risk is compared with risk criteria. In many organisations, the level of risk is estimated by scores and, then, risk treatment plans prioritised accordingly (Cox 2009). The risk scoring mechanism has been a base for several risk management tools and techniques, such as Failure Mode and Effect Analysis (FMEA), Risk Matrices (RM) and Hazard and Operability Analysis (HAZOP) (Cox 2009; Kaya et al. 2019).

FMEA has been widely used in a range of industries, including defence, aerospace, automotive and healthcare (Anes et al. 2018; Lago et al. 2012; Simsekler et al. 2019). FMEA enables a systematic analysis of the risks associated with failure modes within a process. The FMEA process involves the identification of failure modes, their causes and potential effects and the estimation of the criticality of each failure mode (BSI 2010). Criticality is estimated through the Risk Priority Number (RPN), which is the product of the multiplication of the occurrence, severity and detectability scores. The higher the RPN, the more critical the failure mode. Consequently, a risk with the higher RPN has a higher priority for risk treatment.

The scoring mechanism translates the linguistic descriptions into numerical values. For instance, a score of 1, in terms of severity, represents "negligible" and 5 represents "catastrophic". On the one hand, this transformation simplifies the risk analysis process by allowing the use of subjective judgement instead of real-life quantitative datasets. In complex systems, obtaining real-life datasets can be challenging. On the other hand, the scoring mechanism might not be appropriate to prioritise risks (Cox 2009; Cox et al. 2005). Various risks, having different priority, might have the same RPN. Different team members might assign different scores for the same risk due to cognitive bias (Anes et al. 2018; Cox 2009). As a result, solely relying on the risk scores can be misleading to make risk prioritisation decisions. For example, one might give a higher priority to a risk, which is related to regulations, even if it has a low RPN. Similarly, one might have a higher priority to the risk that has a low-cost treatment plan.

In the literature, several solutions have been proposed to overcome the shortcomings of the scoring mechanism, and, in turn, the challenges with risk prioritisation. Researchers used fuzzy approach to determine the uncertainty in scoring and used Multi-Criteria Decision-Making (MCDM) methods to support risk prioritisation decisions (Fattahi and Khalilzadeh 2018; Gul et al. 2017; Mandal et al. 2015; Neslo et al. 2017). MCDM methods have been widely used by researchers to prioritise alternatives by considering conflicting criteria. However, such methods have still been criticised in terms of their reliability (Asadabadi et al. 2019). Risk prioritisation decisions might not always follow a linear way of thinking. Decision-makers might prefer using their intuitions.

In healthcare, the risk prioritisation process highly depends on the risk scores. If a risk is categorised as low (having a low-risk score), it is often expected to be resolved by the front-line staff. If the risk is categorised as high (having a high-risk score), it is expected to be resolved by the hospital management. As a result, more attention has been paid on the treatment of high risks (Kaya et al. 2019). However, a risk having a lower risk score might still have a higher priority than a risk having a higher risk score. In practice, expert judgements might help recognise such risks, but experts might give a conflicted decision by using their intuitions. At that instance, relying on the risk scores or RPNs or even MCDM methods might not be a reliable approach. This study compares the findings of the expert judgement, RPN and MCDM methods to prioritise ten actions proposed for the treatment of five risks in the drug administration process.

2. Methods

This study used the findings of another study to identify risks in the drug administration process and recommended actions for their treatment (Table 1)(Lago et al. 2012).

Table 1. Selected risks and recommended actions in the drug administration process

Failure mode/ Risk	Recommended actions
F1. Wrong drug dose calculation	R1. Preparing prescriptions in a quiet room R2. Designing a standard Table for doses and dilution processes R3. Creating a mobile application to guide for dose calculations
F2. Wrong drug delivery	R4. Filling a checklist before delivering the drugs R5. Designing a barcode system for the drug dispatch process
F3. A transcription error in drug prescription	R6. Getting an electronic prescription system to prevent transcription errors
F4. Failure to notify the responsible	R7. Requiring compulsory written and verbal communication during the handover process R8. Getting an electronic patient monitoring system and providing a screen next to each patient bed.
F5. Wrong drug dilution	R9. Creating a guideline for drug dilution process R10. Creating a standard Table that enables the nurse to take all essential notes for correct dilution

In this study, two Subject Matter Experts (SME) (i.e. a nurse and a doctor) are involved to prioritise ten actions by following three different approaches (i.e. expert judgement, RPN and MCDM methods).

The study used MCDM methods: the Analytical Hierarchy Process (AHP) to weight the selected nine criteria (Figure 1)(Saaty 1987) and the VIKOR to prioritise the actions (Opricovic and Tzeng 2004). The SMEs were provided with a questionnaire to determine the weights of three primary and nine sub-criteria. SMEs used Saaty's 1 to 9 scale to estimate the importance of each criterion by comparing one to another. Besides, SMEs were provided with another questionnaire to assess how each action complies with nine criteria. Data obtained from these questionnaires were used to apply AHP and VIKOR methods, and, therefore, to prioritise the risk treatment actions.

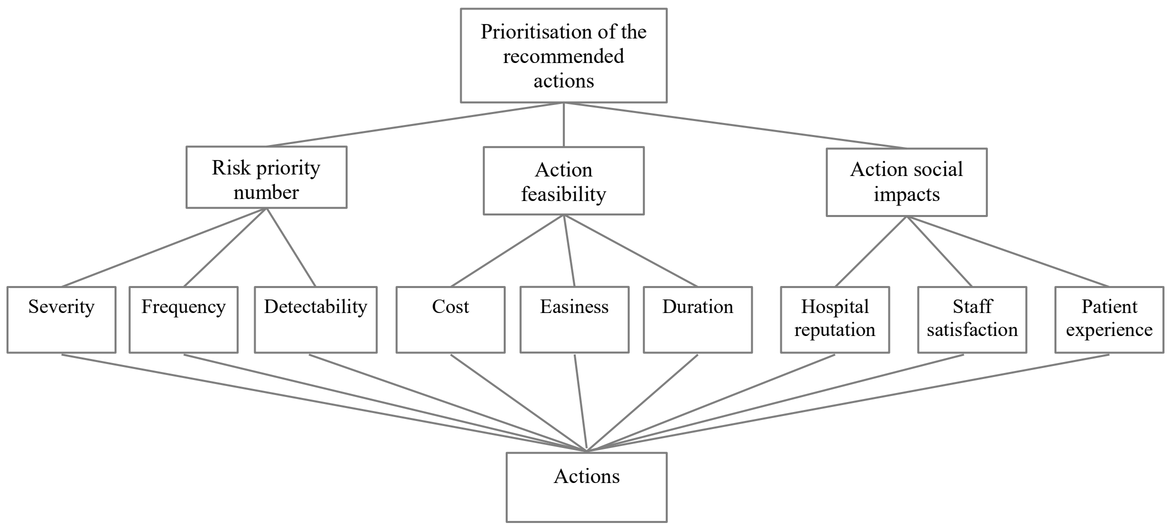

Figure 1. A hierarchical model for the prioritisation of the recommended actions

A score from 1 to 5 has been used to categorise each criterion (NPSA 2008; Perks et al. 2012). Table 2 represents the linguistic descriptions of each score. SMEs assigned scores for each recommendation by using Table 2.

Table 2. The linguistic descriptions of each score

Category	The descriptions of the scores				
	1	2	3	4	5
Severity (S)	Negligible	Minor	Moderate	Major	Catastrophic
Frequency (F)	Rare	Unlikely	Possible	Likely	Almost certain
Detectability (D)	Very easy to detect	Easy	Moderate	Difficult	Almost impossible
Cost (C)	Very high	High	Moderate	Low	Very low
Easiness (E)	Almost impossible	Difficult	Moderate	Easy	Very easy to implement
Duration (D)	The time required very high	High	Moderate	Low	Very low

The impact on hospital reputation (HR)	Very low	Low	Moderate	High	Very high
The impact on staff satisfaction (SS)	Very low	Low	Moderate	High	Very high
The impact on patient experience (PE)	Very low	Low	Moderate	High	Very high

Additionally, SMEs were used their expert judgements to prioritise the actions without the use of other methods. This approach was aimed to validate the findings from RPN and MCDM methods. Following that, the findings from three approaches (i.e. expert judgement, RPN and MCDM methods) were compared.

3. Results

SMEs provided data required to undertake AHP. Table 3 provides weights calculated for each criterion. The findings reveal that the most critical criterion in risk prioritisation is the effect of the recommended action on hospital reputation.

Table 3. The global weights of all criteria

Main criteria	Local weight	Sub-criteria	Local weight	Global weight
C1. Risk priority number	0,28	C1.1. Severity	0,62	0,174
		C1.2. Frequency	0,28	0,08
		C1.3. Detectability	0,10	0,028
C2. Action feasibility	0,07	C2.1. Cost	0,69	0,05
		C2.2. Easiness	0,08	0,006
		C2.3. Duration	0,23	0,02
C3. Action social impact	0,65	C3.1. Hospital reputation	0,62	0,403
		C3.2. Staff satisfaction	0,10	0,065
		C3.3. Patient experience	0,28	0,182

SMEs assigned a score from 1 to 5 to each recommended action regarding all nine sub-criteria (Table 4). Data obtained from Table 4 have been used to apply VIKOR, and, in turn, to make the comparisons. The data also provided RPN values for each action.

Table 4. The scores and rankings assigned by the SMEs

Recommended actions	Risk priority number (RPN)			Action feasibility			Action social impacts			RPN SxFxD	Multiply all nine criteria	SMEs ranking
	S	F	D	C	E	D	HR	SS	PE			
R1.	5	2	5	5	4	5	2	3	1	50	30.000	7
R2.	5	2	5	5	3	3	2	3	2	50	27.000	6
R3.	5	2	5	3	2	2	3	4	2	50	14.400	5
R4.	3	3	2	5	4	4	2	2	1	18	5.760	10
R5.	3	3	2	2	2	2	4	4	2	18	4.608	3
R6.	4	3	3	2	2	2	3	4	1	36	3.456	4
R7.	5	3	4	5	4	5	2	2	2	60	48.000	1
R8.	5	3	4	2	2	2	4	4	4	60	30.720	2
R9.	5	2	5	4	3	3	2	2	1	50	7.200	9

R10.	5	2	5	5	4	4	2	2	2	50	32.000	8

Figure 2 shows the comparisons for the rankings of recommended actions. The comparisons were made among the findings of the VIKOR method, RPN, expert judgement and simple multiplication of all scores assigned for each sub-criterion.

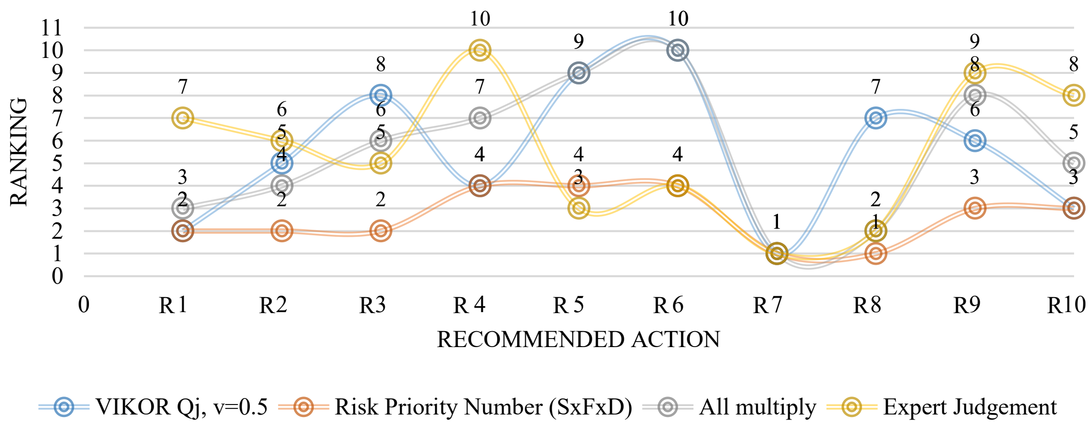

Figure 2. The comparison for the rankings of all recommendations

4. Discussion and Conclusion

The findings revealed that all approaches have the same result for the first ranked recommended action. However, there were few overlaps at the rest of the rankings. This can be explained that it is easier to differentiate the best and the worst cases. Everything in the middle is just to set a border between the best and the worst. A similar way of thinking is also applied when using risk matrices. Researchers claim that risk matrices are only capable of differentiating the lowest and highest risks, and everything in the middle is almost like random (Cox 2008, 2009; Kaya et al. 2019). This was due to the unreliability of risk scoring and the design of risk matrices.

In this study, most of the recommended actions were assigned the same RPN value. Thus, RPN rankings were not distinctive to make prioritisation decisions. However, multiplying all nine scores for each recommended action revealed more distinctive results. This simple multiplication of all scores also gave the closest rankings to the findings of the expert judgement. So, should we keep relying on the expert judgement in risk prioritisation? In healthcare, expert judgement is often used to make decisions despite being subject to many biases. Using expert judgement can still be useful, especially when there is high uncertainty (Agnew et al. 2006).

In risk prioritisation, multiple factors should be determined. This is intuitively applied in the use of expert judgement. Howbeit, researchers suggested the use of MCDM methods to make prioritisations in risk management. MCDM methods use both mathematical models and expert judgements. Several researchers have already integrated MCDM methods into traditional risk management methods to make reliable decisions (Kuo et al. 2012; Mandal et al. 2015).

Although this study applied VIKOR to prioritise recommended actions, different MCDM methods could have ranked the actions in different orders. In literature, researchers have also questioned the importance of the selection of the MCDM: "Was it the selection of the MCDM methods?" (Asadabadi et al. 2019; Chitsaz and Banihabib 2015). Studies can be found to approve either way

(Chitsaz and Banihabib 2015; Triantaphyllou 2000). So, one might ask if different MCDM methods solve the same problem differently, how to rely on these methods? Asadabadi et al. (2019) questioned the potential benefits of the use of MCDM methods and even claimed that such techniques are not frequently used in practice. Indeed, such methods are not to make decisions; they are to support decision-making.

This study followed three different approaches to prioritise risks, and, in turn, recommended actions for the treatment of the risks. The findings provided different rankings of the priority of the recommended action, except the one selected as having the highest priority. This made the author question the potential benefits and limitations of every single of the approaches. It is difficult to give a straight-forward answer in decision making, especially in complex systems. It is, therefore, many researchers integrated multiple techniques to make decisions in the field of risk management.

While this study raised some issues in risk prioritisation, the limitations of this study should also be mentioned. This study used an ordinal scale instead of real-life data to evaluate each recommended action regarding the selected nine criteria. The use of real-life data would have ended up with different rankings. Besides, using an ordinal scale to collect data itself subjects to bias. The quality of the data is of the utmost importance in decision-making. However, it is challenging to obtain real-life data in complex systems, as in healthcare. Future studies might use a fuzzy approach to determine uncertainty and minimise subjective bias in the analysis.

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Biography

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