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RESEARCH ARTICLE

PRIORITIZING EMERGENCY MANAGEMENT PHASES IN ELEMENTARY SCHOOLS: A CASE STUDY USING TECHNIQUE FOR ORDER OF PREFERENCE BY SIMILARITY TO IDEAL SOLUTION (TOPSIS)

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ABSTRACT - Emergency management is critical to ensuring the safety and well-being of students, teachers, and staff in educational institutions. The purpose of this study is to prioritize the emergency management phases of mitigation, response, preparedness, and recovery in three selected elementary schools, with a focus on fire incidents. The method used is The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). The result showed that School 2 prioritized a robust response strategy due to its central city location, while School 1 focused on mitigation because of its proximity to a fire station. School 3 emphasized preparedness, given its rural location and predominantly low-income student population. The study's findings underscore the importance of tailored strategies for educational institutions, emphasizing response strategies and preparedness.

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INTRODUCTION

In Malaysia, a country renowned for its diverse landscapes and vibrant communities, the importance of emergency management in schools cannot be overstated (Ahmad, 2019). Every day, countless young minds gather within the walls of educational institutions, eager to learn, grow, and shape the future. However, as responsible educators and caretakers, it is a duty of all to ensure their safety and well-being in the face of potential emergencies or disasters (Ministry of Education. 2013). The implementation of effective emergency management protocols becomes paramount. Educational institutions play a pivotal role in shaping the minds and futures of students. They serve as not only centers of learning but also as environments where young individuals can thrive, explore, and feel safe. As students spend a significant portion of their time within these institutions, it is paramount that they are considered the safest places for them. This safety extends to various aspects, including protection from physical harm, psychological well-being, and the ability to respond effectively in emergencies, such as fire incidents.

On 22 September 2023, it was reported that a fire broke out at Permatang Tok Kandu National Elementary School in Permatang Pauh, Penang, West Malaysia. The fire has damaged 5 classrooms, where 3 of which were destroyed. Though there were no casualties, the students, teachers, and staff were significantly impacted by this event (Mohamad, 2023). This highlights the urgent need for effective fire safety measures and comprehensive emergency management protocols in schools (Wilburg, 2023). By establishing and maintaining effective fire emergency management systems, educational institutions can fulfill their responsibility to provide a haven for students. This commitment encompasses proactive measures to prevent fires, preparedness to respond swiftly and efficiently, and comprehensive recovery plans to aid the affected individuals and restore normalcy. Ensuring that educational institutions are equipped with the necessary fire safety measures safeguards the well-being of students and staff, fostering an environment conducive to learning and personal growth.

LITERATURE REVIEW

Educational establishments must be equipped with a range of life safety devices that contribute to the protection of individuals and property. Examples of such systems include fire detection systems that alert occupants to evacuate, as well as fire suppression systems that help control the fire until the arrival of firefighting services. These systems undergo regular inspections, tests, and maintenance by facilities management to ensure their proper functioning. However, there are steps you can take to support these efforts. Each educational institution should have essential emergency safety equipment in place, including fire extinguishers, smoke detectors, fire alarm systems, emergency exit routes, and water sprinklers. This equipment plays a vital role in safeguarding the well-being of occupants, particularly students, and minimizing potential property damage (Mohd Fauzi, 2021). It is the goal of mitigation measures to reduce the severity of

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the damage caused by fire events. The necessity of conducting routine fire risk assessments and implementing preventive safety measures to reduce the likelihood that educational institutions will be impacted by fires. Education is the main way for students to obtain knowledge of fire protection (Zakaria et al., 2019).

According to the findings of Williams et al. (2019), educational institutions have specific requirements that must be taken into account, while developing and maintaining their emergency response plans. Training that emphasizes hands-on practice and simulations allows participants to hone their abilities in a safe setting, thereby improving their capacity for preparedness and reaction. The community must be provided with training to retain an adequate level of fire safety knowledge and the importance of maintaining functional fire safety equipment (Brennan, 1999; DiGuiseppi et al., 2002; Mallonee et al., 1996 as cited in Secer & Satyen, 2006). Typical situation evacuation plans include means of egress, safe locations, and detailed instructions for each form of emergency.

Emergency response refers to the coordinated efforts and actions taken to respond to and mitigate the effects of various categories of emergencies, such as natural disasters, accidents, and public health crises. According to Adger et al. (2018), emergency response is an extremely important factor in both the development of community resilience and the facilitation of post-event rehabilitation. First aid plays a crucial role in emergency response by providing immediate medical care to those who have been injured or become unwell during an emergency. It assists in stabilizing injured or ailing patients until professional medical assistance arrives. It consists of administering necessary interventions such as cardiopulmonary resuscitation (CPR), regulating bleeding, managing fractures, and responding to common medical emergencies (Mould-Millman et al., 2018).

Understanding the psychological response of individuals and communities during and after emergencies is essential for effective emergency management and recovery. Depending on the nature of the emergency, the level of exposure, and the individual's characteristics, the severity and duration of these reactions can vary (Pfefferbaum et al., 2014).

METHODS AND MATERIALS

Secondary Data

The study encompasses a diverse range of topics, offering an in-depth analysis of key elements such as mitigation, preparedness, response, and recovery within the context of emergency management in educational institutions. Leveraging this existing research serves as a foundational step in understanding the current landscape and trends in the field, contributing to the overall contextualization of the study's objectives and methodology.

The survey questionnaire for this study was meticulously crafted based on an extensive review of relevant literature from reputable journals, ensuring that it effectively captures the essential elements identified in the existing body of knowledge. Three expert validators were engaged to provide critical input. The validation criteria were carefully defined to assess the survey's clarity, comprehensiveness, and relevance. Clarity was gauged by evaluating the language and structure of the questions to ensure they were easily understandable. The feedback and recommendations provided by these experts were invaluable in refining the survey instrument, ensuring its effectiveness in capturing meaningful insights for the study.

The survey instrument was distributed to a total of 29 participants, comprising 24 teachers from three Elementary Schools (8 teachers represented each school) located in the Southern Region of West Malaysia, respectively, along with 5 experts from the industry. This diverse participant pool aimed to capture perspectives from both educational practitioners and industry professionals, ensuring a comprehensive understanding of emergency management elements in educational institutions. Simultaneously, the participation of 5 industry experts brought a broader perspective to the survey, incorporating insights from professionals with practical experience in emergency management beyond the academic realm. The engagement of both teachers and industry experts in the survey process ensured a well-rounded evaluation of emergency management elements, aligning with the study's objective to comprehensively assess and prioritize these elements.

The Technique for Order of Preference by Similarity to Ideal Solution

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a technique for evaluating and ranking alternatives according to multiple criteria. TOPSIS considers both the positive and negative characteristics of each alternative and calculates their proximity to the optimal solution. The ideal solution has the highest performance values for all criteria, whereas the negative ideal solution has the lowest performance values. By comparing the distances of alternatives to these ideal solutions, TOPSIS produces a relative closeness value for each alternative, enabling their ranking.

The normalization process adopted in this study involves the use of z-scores, which refers to the process of normalizing every value in the dataset such that the mean of all the values is 0 and the standard deviation is 1 (Zach, 2021). For each criterion and each expert/school, the z-score is calculated by subtracting the mean of the respective criterion from the raw score and then dividing by the standard deviation:

$$Z = \frac{(X - \mu)}{\sigma} \quad (1)$$

where X is the raw score, μ is the mean and σ is the standard deviation. In the context of TOPSIS, the calculation of weight involved assigning weights to each criterion where each of the elements was assigned a weight of 0.25, reflecting an equal distribution of importance across the four elements

$$V_{ij} = \bar{X} \times 0.25 \tag{2}$$

where X¯is the normalized matrix. Then, the two Euclidean distances were calculated, followed by the calculation of the relative closeness to an ideal solution to rank the elements. The two Euclidean distances and relative closeness to an ideal solution are determined as follows:

$$S^{+} = \left[\sum_{j=1}^{m}\left(V_{ij} - V^{+}\right)^{2}\right]^{0.5} \tag{3}$$

$$S^{-} = \left[\sum_{j=1}^{m}\left(V_{ij} - V^{-}\right)^{2}\right]^{0.5} \tag{4}$$

$$P = \frac{S^{-}}{S^{+} + S^{-}} \tag{5}$$

Where S^+ is the Euclidean distance from the ideal best, S^- is the Euclidean distance from the ideal worst and *P* is the relative closeness to the ideal solution.

RESULTS AND DISCUSSION

The Recent Development of Emergency Management

The recent research emphasizes the importance of proactive mitigation strategies in schools. Disaster mitigation encompasses protective actions and activities undertaken prior to, during, and following a disaster, including the prevention of disaster-related dangers, rescue efforts, rehabilitation, and relocation (Triastari et al., 2021). Mitigation, or actions to reduce or eliminate the impact of hazards, has grown in popularity as school increasingly recognizes the long-term benefits of investing in preventative measures (Smith et al., 2022). This is consistent with the global trend toward risk reduction, in which schools are encouraged to assess and improve their physical infrastructure and community resilience.

While mitigation is critical, the literature also emphasizes the importance of comprehensive preparedness measures. The current discourse suggests a more nuanced understanding of preparedness, considering not only technical aspects but also the psychological and emotional well-being of students and faculty during crises. The increased emphasis on response dynamics during emergencies is one notable trend in recent literature. According to the literature, there is a growing recognition of the need for adaptive and flexible response strategies in educational settings to address the diverse nature of emergencies (Thornhill-Miller et al., 2023).

TOPSIS Result Analysis using MICROSOFT EXCEL

In this study, data were collected via a comprehensive questionnaire with criteria encompassing mitigation, preparedness, response, and recovery, which were transformed systematically. This information is organized into a structured matrix, where each school and experts become an alternative and the performance levels across the criteria mentioned above are assigned numerical values. This section explains the critical steps involved in this preliminary phase, including how raw data is refined into a format suitable for the rigorous TOPSIS analysis that follows.

The process of normalizing the data matrix is a critical step in preparing data for TOPSIS analysis. Normalization is the process of adjusting values measured on different scales to a nominally common scale, which serves the critical purpose of ensuring fair comparison across different criteria by eliminating any bias that may arise due to varying scales. The normalization process adopted in this study involves the use of Z-scores, which refers to the process of normalizing every value in the dataset such that the mean of all the values is 0 and the standard deviation is 1 (Zach, 2021). Table 1 shows the average, standard deviation, and Z scores for the mitigation, preparedness, response, and recovery phases.

In the context of TOPSIS, the calculation of weight involved assigning weights to each criterion where each of the elements was assigned a weight of 0.25, reflecting an equal distribution of importance across the four elements. The calculated weighted normalized matrix from the feedback of all respondents is shown in Table 2.

Table 1. Average, standard deviation, and Z-Scores for mitigation, preparedness, response, and recovery phases

Respondent	Mitigation			Preparedness			Response			Recovery		
	Average	SD	Z-Score	Average	SD	Z-Score	Average	SD	Z-Score	Average	SD	Z-Score
Expert 1	1.068	0.258	-0.258	2.667	1.500	1.556	2.833	1.946	-0.942	2.833	1.946	-0.942
Expert 2	3.067	1.792	0.521	3.888	1.764	0.629	2.667	2.059	-0.809	2.667	2.059	-0.809
Expert 3	2.068	0.962	0.971	2.000	1.000	1.000	2.333	0.984	-0.338	2.333	0.985	-0.338
Expert 4	1.533	0.516	0.904	2.555	0.527	0.843	2.500	0.904	-1.658	2.500	0.905	-1.658
Expert 5	1.600	0.738	-0.814	2.777	0.833	1.467	3.000	0.853	0.000	3.000	0.853	0.000
School T1A	1.333	0.488	1.366	1.889	0.333	0.333	2.000	0.603	0.000	2.000	0.603	0.000
School T1B	2.933	0.258	0.258	1.111	0.333	-0.333	1.417	0.515	-0.809	1.417	0.515	-0.809
School T1C	1.133	0.352	-0.379	2.444	0.527	-0.843	2.667	0.492	-1.354	2.667	0.492	-1.354
School T1D	1.067	0.258	-0.258	1.111	0.333	-0.333	2.167	0.835	0.998	2.167	0.835	0.998
School T1E	2.133	0.743	-1.525	1.333	0.500	-0.667	1.500	0.522	-0.957	1.500	0.522	-0.957
School T1F	1.867	0.743	-1.166	1.556	0.726	0.612	3.167	0.835	-0.200	3.167	0.835	-0.200
School T1G	1.533	0.640	-0.833	1.556	0.527	-1.054	3.083	0.289	-0.289	3.083	0.289	-0.289
School T1H	2.200	0.414	-0.483	1.889	0.782	0.142	3.000	0.426	0.000	3.000	0.426	0.000
School T2A	2.533	0.516	0.904	2.333	0.500	-0.667	2.917	0.669	-1.371	2.917	0.669	-1.371
School T2B	2.267	0.458	-0.583	2.222	0.441	-0.504	3.167	0.577	-0.289	3.167	0.577	-0.289
School T2C	1.733	0.799	0.334	2.000	0.500	0.000	3.167	0.577	-0.289	3.167	0.577	-0.289
School T2D	2.400	0.632	-0.632	2.111	0.601	-0.185	2.667	0.888	-1.878	2.667	0.888	-1.878
School T2E	2.067	0.594	-0.112	2.556	0.527	-1.054	3.000	0.603	0.000	3.000	0.603	0.000
School T2F	2.133	0.640	1.354	2.111	0.601	1.479	3.583	0.515	-1.133	3.583	0.515	-1.133
School T2G	1.867	0.743	0.179	1.778	0.833	1.467	2.667	0.492	0.677	2.667	0.492	0.677
School T2H	1.800	0.414	0.483	2.111	0.601	-1.849	2.583	0.996	1.422	2.583	0.996	1.422
School T3A	1.933	0.458	0.146	2.222	0.441	-0.504	2.583	0.515	0.809	2.583	0.515	0.809
School T3B	2.000	0.655	-1.528	2.000	0.500	0.000	2.667	0.651	0.512	2.667	0.651	0.512
School T3C	2.000	0.535	1.871	2.222	0.441	-0.504	3.167	0.577	-0.289	3.167	0.577	-0.289
School T3D	2.200	0.414	-0.483	2.222	0.441	-0.504	2.333	0.492	1.354	2.333	0.492	1.354
School T3E	1.933	0.458	0.146	1.556	0.527	0.843	2.750	0.622	0.402	2.750	0.622	0.402
School T3F	1.400	0.507	-0.789	1.667	0.500	0.667	2.333	0.492	-0.677	2.333	0.492	-0.677
School T3G	1.867	0.516	0.258	1.889	0.333	0.333	2.833	0.389	0.428	2.833	0.389	0.428
School T3H	1.867	0.352	0.379	2.444	0.527	-0.843	2.917	0.289	0.289	2.917	0.289	0.289

Table 2. Weighted normalized matrix (expert, school 1, school 2 & school 3)

Respondent	Mitigation	Preparedness	Response	Recovery
Expert 1	-0.0645	0.3889	-0.2355	0.1250
Expert 2	0.1302	0.1575	-0.2023	0.1250
Expert 3	0.2428	0.2500	-0.0846	0.1250
Expert 4	0.2259	0.2108	-0.4146	-0.1250
Expert 5	-0.2036	0.3667	0.0000	-0.1250
School T1A	0.342	0.083	0.000	0.217
School T1B	0.065	-0.083	-0.202	-0.125
School T1C	-0.095	-0.211	-0.339	-0.217
School T1D	-0.065	-0.083	0.250	-0.375
School T1E	-0.381	-0.167	-0.239	-0.375
School T1F	-0.292	0.153	-0.050	0.125
School T1G	-0.208	-0.264	-0.072	0.000
School T1H	-0.121	0.036	0.000	0.217
School T2A	0.226	-0.167	-0.343	-0.217
School T2B	-0.146	-0.126	-0.072	-0.125
School T2C	0.083	0.000	-0.072	0.375
School T2D	-0.158	-0.046	-0.469	-0.125
School T2E	-0.028	-0.264	0.000	0.125
School T2F	0.339	0.370	-0.283	0.217
School T2G	0.045	0.367	0.169	0.375
School T2H	0.121	-0.462	0.356	-0.306
School T3A	0.036	-0.126	0.202	-0.125
School T3B	-0.382	0.000	0.128	0.125
School T3C	0.468	-0.126	-0.072	0.217
School T3D	-0.121	-0.126	0.339	-0.217
School T3E	0.036	0.211	0.101	0.000
School T3F	-0.197	0.167	-0.169	0.125
School T3G	0.065	0.083	0.107	-0.375
School T3H	0.095	-0.211	0.072	0.125

Then, the two Euclidean distances were calculated, followed by the calculation of the relative closeness to the ideal solution to rank the elements. The lower the values are considered better and are rank first.

The TOPSIS analysis revealed that, according to the experts and School T2, the response phase is identified as the most significant element in the emergency management cycle. The focus on prompt actions and issuing timely warnings underscores its importance, justifying its position as the most influential factor in emergency management within elementary schools. This is especially relevant for School T2, located in the heart of the city, as its exposure to a variety of potential risks requires a well-prepared and responsive strategy. The school's central urban location, coupled with its proximity to first responders, reinforces the need for rapid and efficient emergency response, ensuring that immediate assistance is available when required. As emphasized by Hosseinia & Izadkhah (2020), effective emergency management depends on the establishment of strong communication networks and the provision of essential tools and resources to emergency responders. For School T2, with its urban setting and high likelihood of emergencies, this proactive approach ensures a swift and well-coordinated response to any crisis, minimizing harm and safeguarding the school community.

In comparison, the TOPSIS analysis for School T1 highlighted mitigation as the most influential element in its emergency management efforts. As Fontana et al. (2020) suggest, one of the most effective strategies to reduce human casualties during disasters is educating teachers, students, and their families about disaster risk reduction. By raising awareness, these stakeholders can work together to protect themselves and others from the impacts of various emergencies. School T1 can minimize the potential damage from disasters such as fires, storms, or floods by implementing well-designed mitigation measures, thereby also reducing the likelihood of these events occurring. Additionally, the school's advantageous location near a fire station is a key asset, supporting its mitigation strategy by ensuring that emergency services can quickly respond to any incidents. This strategic placement of the school further enhances its efforts to minimize harm and demonstrates a forward-thinking approach to emergency preparedness.

In conclusion, preparedness was ranked as the most influential element in the emergency management cycle for School T3, according to its TOPSIS analysis. This priority is particularly crucial given the specific characteristics of School T3,

which is located at a rural area and serves a predominantly low-income student population. In this context, preparedness is key to ensuring the safety of the school community. Training sessions, including regular drills and exercises, are essential to equipping staff and students with the skills and knowledge needed to respond effectively in the event of an emergency. Moreover, gathering and securely storing the necessary emergency supplies is critical to ensure readiness when disaster strikes, as noted by Hosseini & Izadkhah (2020). The rural setting of School T3 presents additional challenges, such as longer response times from emergency services, which makes it even more important for the school to maintain a high level of preparedness. Education and training, as highlighted by Shah et al. (2020), play a vital role in empowering individuals to manage risks and act decisively in emergencies, ultimately enhancing the school's resilience and ability to handle crises effectively.

CONCLUSION

This comprehensive study focused on prioritizing emergency management elements in educational institutions. Using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), the research investigated recent developments in emergency management research in elementary schools. The study provided a nuanced understanding of the evolving landscape in educational institutions, emphasizing the relevance of findings to current practices and challenges. TOPSIS analysis identified the most influencing and least influencing factors in emergency management, with a focus on response, preparedness, recovery, and mitigation. Insights from the analysis highlighted the critical importance of a robust response strategy for a centrally located School T2, while School T1 prioritized mitigation due to its proximity to a fire station. School T3, located in a rural area, prioritized preparedness for its predominantly low-income student population. The study contributes to the field by emphasizing the significance of response strategies and preparedness measures in emergency management, especially in elementary school. The comparison between expert opinions and school perspectives underscores the complexity of decision-making, highlighting the need for tailored strategies in educational institutions. The findings aim to inform future strategies, policies, and practices, promoting more resilient and effective emergency management in educational settings.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

AUTHORS CONTRIBUTION

A. Ramli is a corresponding author: Conceptualization, Writing – review and editing.

Z. Adlin Adriana is a main author: Methodology, Visualization, and Writing – review and editing.

D. Rindang and I. Al Khowwas: writing, review and editing

AVAILABILITY OF DATA AND MATERIALS

The data supporting this study's findings are available on request from the corresponding author

ETHICS STATEMENT

'Not applicable'

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