

PERCEIVED RISK-BASED MAINTENANCE MANAGEMENT (PRBMM) FOR PUBLIC SCHOOLS: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Perceived risk is important to identify the appropriate improvements needed for maintenance management in public schools. Addressing perceived risk in public schools highlights the importance of considering it to enhance facility performance and sustainability. School building maintenance is a global issue that needs immediate attention, as poor maintenance can compromise a school's safety. This should not undermine the school's mission of providing quality education to all occupants while ensuring productivity and comfort through effective building maintenance management. This study aims to address the gap in current maintenance management practices by investigating the role of perceived risk in enhancing maintenance management in public schools. The primary objective is to develop a conceptual model based on Perceived Risk-Based Maintenance Management (PRBMM), which prioritizes maintenance tasks according to perceived risk, thereby improving facility performance and sustainability. A systematic literature review was conducted after a comprehensive search of research papers from 2009 to 2024 on perceived risk in risk-based maintenance management. The search included databases such as Scopus, Web of Science (WoS), Elsevier, Google Scholar, and Science Direct using



keywords such as (“Perceived Risk”) AND (“Maintenance Management”) and (“Risk-Based Maintenance Management”) and (“Public School”). The searcher identified 1,165 articles based on the search term of 150 articles in Scopus, 200 articles in WoS, 155 articles in Elsevier, 230 articles in Google Scholar, 430 articles in Science Direct, and 1,155 were excluded. This research highlights the necessity of investigating the relationships between perceived risk and Risk-Based Maintenance Management (PRBMM), focusing on responses to PRBMM approaches. As a result, a conceptual model centred on PRBMM is proposed.

Keywords: *Maintenance, Management, Perceived-Risk, Public School, Risk-Based, Systematic Literature Review*

INTRODUCTION

Maintenance of public schools is essential for functionality, safety, and learning. Effective management necessitates routine maintenance, significant repairs, and renovations; however, chronic underfunding frequently presents obstacles. As a result of inadequate financial resources, educational institutions are compelled to implement reactive repair strategies, which exacerbate the backlog of maintenance and upkeep (Arif, Bayraktar, & Chowdhury, 2016; Beauregard & Ayer, 2018; Barrie Chanter & Swallow, 2008; Mohamed, Osman, & Tran, 2022). Inadequate execution of maintenance protocols leads to suboptimal utilisation of resources and the progressive escalation of minor complications to significant challenges (Abdullah & Bakri, 2021; Arshad, Ali, Fauzi, & Ihsan, 2023; Hassanain, Al-Zahrani, Abdallah, & Sayed, 2019).

One of the critical gaps identified in current maintenance management practices is the lack of reliable data and effective risk assessment techniques (Dzulkifli et al., 2021; Ensafi & Thabet, 2021), which impedes informed decision-making and leads to suboptimal prioritisation of maintenance tasks (Tunji-Olayeni, Kajimo-Shakantu, Ayodele, & Babalola, 2023). This research addresses this gap by introducing a Perceived Risk-Based Maintenance Management (PRBMM) approach, which prioritises maintenance tasks based on perceived risks. The objective of this study is to enhance the efficiency and effectiveness of maintenance management in

public schools through a more strategic and data-driven approach.

This study makes a significant contribution to the existing body of knowledge by proposing PRBMM as an innovative framework for improving maintenance management in public schools. The research findings strongly suggest that implementing PRBMM could lead to more efficient maintenance practices, ultimately enhancing the safety and functionality of school facilities. In addition, this study not only addresses a critical research gap by introducing a novel maintenance management strategy but also provides practical implications for optimising resource utilisation and risk management in public school facilities. The findings highlight the transformative potential of PRBMM in educational institutions, marking it as a vital advancement in the field.

LITERATURE REVIEW

This section begins by establishing the theoretical foundations that underpin the study of perceived risk and its integration into maintenance management strategies. Additionally, it explores the integration of Risk Theory (RT) and the Theory of Planned Behaviour (TPB) to develop a comprehensive framework that addresses the challenges and opportunities associated with implementing PRBMM in educational facilities.

The theory of perceived risk is a fundamental framework for comprehending actions that are undertaken to reduce adverse consequences (Bauer, 1960). Two dimensions comprise perceived risk, according to Tsurkan-Saifulina, (2022), danger (the consequence of unfavourable outcomes) and chance (the probability of such outcomes occurring). Numerous researchers have examined the rapid evolution of risk theory (Aven, 2016; Ayyub & Popescu, 2003; Elvik, 2013; Mitchell, 1992). Risk is defined as the probability that adverse consequences will ensue as a result of human or natural activities (Abt, Rodricks, Levy, Zeise, & Burke, 2010; S. Kaplan & Garrick, 1981; Paustenbach, 2024; Williams & Paustenbach, 2024; Zhang et al., 2023). Meanwhile, perceived risk (PR) is quantified by the degree of unpredictability and probability of adverse consequences (Hamilton, 2024; Kamboj, Matharu, & Shukla, 2024; Sohn, 2024; Vieira, Alén, Fernandes, & Rodrigues, 2024).

An improved ability to model behaviour intentions in PRBMM is facilitated by the incorporation of various types of PR—including operational, safety, performance, time, psychological, financial, and social risks—into PR (Klerck & Sweeney, 2007; Mitchell, 1992). Some scholars emphasise PR factors such as financial, operational, safety, and performance risks (L. B. Kaplan, Szybillo, & Jacoby, 1974; S. Kaplan & Garrick, 1981). The present study investigates the perspectives of occupants, facility managers, building owners, and maintenance personnel concerning adverse consequences resulting from maintenance procedures. Prioritising maintenance tasks, allocating resources, and making decisions are all dependent on PR in PRBMM. This requires considering failure probability, financial implications, risks, and the impact on building performance and efficiency.

Ajzen and Fishbein developed the theory of reasoned action (TRA) in 1975 to explain rational human behaviour, focusing on voluntary decision-making. To address mandatory behaviour, the Theory of Planned Behaviour (TPB) included perceived behavioural control (PBC) (Ajzen, 2020). Fishbein and Ajzen (1975), assert that attitudes and societal norms shape intentions, which in turn limit behaviour. To overcome the limitations of TRA, PBC was added to target situations where people have little control over their behaviour. TPB outperforms TRA in social behaviour because it includes volitional control. However, TRA lacks operationalized variables that affect PBC, attitude, and subjective norms. The assumption of proximity between intention and behavior further complicates behavior prediction.

This issue was addressed by deconstructing the Theory of Planned Behaviour (TPB) into the Decomposed Theory of Planned Behaviour (DTPB), which quantifies attitudes, norms, and control beliefs (Taylor & Todd, 1995). Many scholars described DTPB as a TPB modification that improves explanation (Ashaari et al., 2025; Shih & Fang, 2004; Tao & Fan, 2017; Taylor & Todd, 1995). Shih and Fang (2004), found that the DTPB model outperformed the TPB and TRA models. Therefore, for the purposed of this research, PBC analyses of perceived risk, TPB, and TRA are used to create a PRBMM model for public schools. Hence, this study also develops research hypotheses and proposes a conceptual model to guide the investigation.

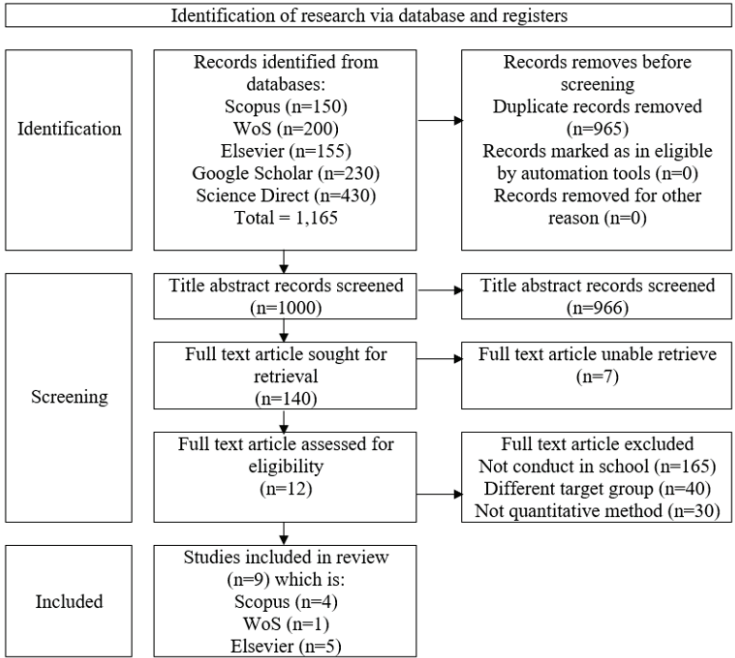
METHODS

Through a systematic literature review (SLR), this study seeks to identify variables that influence perceived risk in risk-based maintenance management (RBMM). The review process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure a comprehensive and transparent approach in data extraction and synthesis. In order to better understand the variables influencing maintenance management and enhance the sustainability and security of school facilities, the SLR examines the literature on PRBMM in public schools. The review includes research articles that meet the following criteria, sourced from Scopus, Web of Science (WoS), Elsevier, Google Scholar, and Science Direct and published between 2009 and 2024.. The methodology for this review involves the following steps:

1. Selection Criteria: Research articles were selected based on the following criteria:
 - Setting: Studies conducted within public school environments.
 - Indexing: Articles indexed in reputable databases, including Scopus, Web of Science (WoS), Elsevier, Google Scholar, and Science Direct.
 - Publication: Articles that adhered to scientific research standards and were published in peer-reviewed journals or conferences.
 - Relevance: Articles with a relevant focus on perceived risk and maintenance management.
2. Search Terms: The search was conducted using specific keywords to ensure comprehensiveness. The search terms included: ("perceived risk") AND ("maintenance management") AND ("risk-based maintenance management") AND ("public school"). This approach was intended to capture a broad range of relevant papers.
3. Data Extraction: Articles that met the criteria were reviewed and analysed to identify key variables and themes related to perceived risk in RBMM. This process involved evaluating the relevance and quality of each study to ensure robust findings.
4. Analysis: The extracted data was synthesised to identify patterns, trends, and gaps in the existing literature. This analysis provided insights into the variables affecting perceived risk and their implications for maintenance management in public schools.

RESULTS AND FINDINGS

Table 1. PRISMA diagram



Source: Author

The SLR identified 1,165 records from the following databases: Science Direct (36.9%), Elsevier (13.3%), Web of Science (17.2%), Scopus (12.9%), and Google Scholar (19.7%). After eliminating 965 duplicates from the 1,000 records initially screened by title and abstract, 966 appropriate records remained. Out of 140 full-text articles sought, seven could not be located. Twelve full-text articles were evaluated, and their eligibility was determined. Among these, 165 were disqualified for not being conducted in educational settings, 40 for focusing on distinct populations, and 30 for not employing quantitative methods. Consequently, nine publications were included in the review, with Scopus contributing 44.4%, Web of Science 11.1%, and Elsevier 55.5%. Following PRISMA guidelines with a 77% compliance rate, the review demonstrated rigorous methodology and transparency. The analysis of nine articles identifies key factors related to perceived risk in risk-based maintenance management.

Table 2 lists the authors, publication years, theories, and factors identified. Table 3 highlights four frequently occurring determinant factors: performance risk (PR), financial risk (FR), safety risk (SR), and operational risk (OR). Among these, operational effectiveness is the most prevalent factor, followed by security and safety measures, facility functionality, equipment and infrastructure, and budget adequacy. Stakeholder satisfaction ranks fourth. Overall, the analysis highlights 20 common factors influencing maintenance management that are essential for enhancing sustainability and safety in public schools. The factors are integrated into research hypothesis and graphically described in a conceptual model as shown in Figure 1.

Table 2. Existing Factors of Perceived Risk

Author(s) (year)	Theory	Factor
(Ain et al., 2024)	Risk Theory	Safety, Financial, Performance, Operational
(Pfortner & Hower, 2022)	Risk Theory	Safety, Financial, Performance, Social
(Sarosa, 2022)	Theory of Plan Behaviour	Financial, Performance, Psychological
(Y. Li, Fan, Zhang, Wei, & Qin, 2023)	Theory of Plan Behaviour	Safety, Financial, Performance, Operational
(Zhai, Li, Hao, Chen, & Kong, 2021)	Theory of Plan Behaviour	Safety, Financial, Performance, Operational
(Vasvári, 2015)	Theory of Plan Behaviour	Safety, Financial, Performance, Operational
(Wijeratne, Perera, & De Silva, 2014)	Risk Theory	Safety, Operational, Performance
(Hommel & King, 2013)	Risk Theory	Performance, Financial, Operational
(Assaf, Hassanain, Al-Hammad, & Al-Nehmi, 2011)	Risk Theory	Safety, Performance, Operational, Financial

Source(s): Researcher's own illustration

Table 3. Determinant factors

Factor of Perceived Risk		1	2	3	4	5	6	7	8	9	Total of Occurrence same factor
		Ain et al.	Pfortner & Hower	Sarosa	Wei et al.	Zhu et al.	T. Voronin	Wijeratne et al.	Hommel et al.	Assaf et al.	
Year		'23	'22	'21	'21	'21	'15	'14	'13	'11	
Performance Risk	Learning environment	✓	✓			✓	✓	✓	✓	✓	5
	Facility functionality	✓	✓			✓	✓	✓	✓	✓	7
	Equipment and infrastructure	✓	✓	✓	✓	✓	✓	✓	✓	✓	7
	Maintenance response time Impact on educational outcomes	✓	✓					✓	✓	✓	4
Financial Risk	Budget adequacy	✓		✓	✓	✓	✓		✓	✓	7
	Funding stability	✓	✓			✓	✓	✓	✓	✓	2
	Cost efficiency	✓	✓			✓	✓	✓	✓	✓	4
	Resource availability Impact on long-term sustainability	✓				✓	✓	✓	✓	✓	3
Safety Risk	Physical hazards					✓	✓		✓	✓	3
	Structural integrity					✓	✓		✓	✓	2
	Health and sanitation					✓	✓		✓	✓	1
	Emergency preparedness					✓	✓		✓	✓	2
	Security and safety measures	✓	✓	✓	✓	✓	✓	✓	✓	✓	8
Operational Risk	Disruption to daily operations					✓	✓	✓	✓	✓	3
	Staff productivity and morale					✓	✓	✓	✓	✓	1
	Student experience	✓	✓			✓	✓	✓	✓	✓	2
	Operational efficiency	✓	✓	✓	✓	✓	✓	✓	✓	✓	9
	Stakeholder satisfaction	✓	✓	✓	✓	✓	✓	✓	✓	✓	6
	Total of occurrence by author	12	9	5	4	11	12	9	10	10	

Source: Author

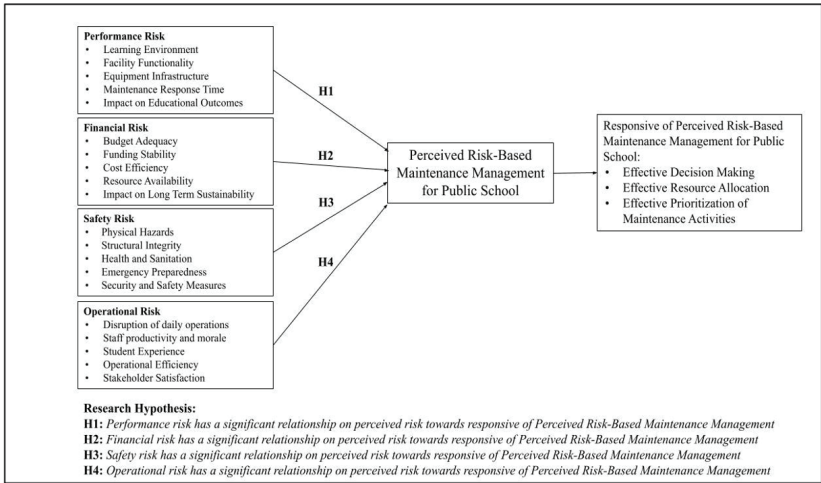


Figure 1. Conceptual Model Formulated based on the Risk Theory (RT), and Theory of Planned Behaviour (TPB)

Source: Author

DISCUSSION

Financial Risk (FR)

Financial risk (FR) in maintenance management encompasses the potential for financial losses or stability issues, which can significantly impact school facilities. Hidden costs, maintenance, and warranties are examples (Kushwaha & Shankar, 2013; Sweeney, Soutar, & Johnson, 1999). Financial impacts include maintenance, replacements, system failures, and building value (Lundgren, 2023). Many scholars also warn of the risk to maintenance budgets, which are essential to schooling (Buban & Janer, 2024; Ismael, 2024; Lawrence, 2003; Sharif, Uzair-ul-Hassan, Parveen, & Ashraf, 2024). Cost efficiency depends on funding stability, resource allocation, and effective expenditure management, while long-term sustainability requires addressing repairs and unexpected issues through reliable funding (Beauregard & Ayer, 2018; Cvetković, Nikolić, & Lukić, 2024; Hassanain et al., 2019; Hauashdh, Nagapan, Jailani, & Gamil, 2024; Myles, 2011; Sayfulloevna, 2023; Yong & Zailan Sulieman, 2015). Deferred or inadequate maintenance threatens school infrastructure sustainability

and poses financial risks (Lavy & Bilbo, 2009). From the researcher's perspective, addressing financial risk involves detailed management of hidden costs, rigorous enforcement of warranties, and strategic resource allocation. Implementing these measures not only enhances budget efficiency but also ensures the long-term stability of school infrastructure, ultimately supporting sustained educational quality.

Performance Risk (PR)

Performance Risk (PR) refers to the perceived potential for unexpected maintenance costs and service failures, which can significantly impact building operations and decision-making processes (Kushwaha & Shankar, 2013; Sweeney et al., 1999). This perception influences maintenance strategies, considering factors such as task complexity, equipment difficulty, and required technical knowledge (C. Li & Li, 2023; Okudan, Budayan, & Dikmen, 2021). For example, high technical complexity in building systems or equipment can lead to maintenance cost overruns and service failures, affecting operational efficiency. Lighting, sound, and comfort within learning environments also play crucial roles in influencing student performance (Heschong, Wright, & Okura, 2002). Therefore, effective maintenance is essential for enhancing school facility functionality and infrastructure, ultimately contributing to improved student success. From the researcher's perspective, addressing performance risks involves implementing robust maintenance strategies, such as regular inspections and upgrades, to minimize disruptions and enhance learning environments. This approach not only mitigates risks but also significantly boosts student performance and success.

Safety Risk (OR)

Safety risks in school maintenance, including physical hazards, structural integrity issues, health and sanitation concerns, emergency preparedness, and security, can lead to accidents, injuries, or fatalities (Al-Worafi, 2024; Chandrappa & Das, 2024; Duhung, Ibrahim, & Puyu, 2024; Janius, Amdan, Kasdiah, Harifin, & Bhari, 2024; Tong et al., 2024). Examples include maintenance accidents, exposure to hazardous materials, poor electrical wiring, uneven floors, unsafe playground equipment, and structural issues like wall cracks and roof collapses (Mubita, 2018; Mubita,

Milupi, Monde, Machila, & Sikayomya, 2024; Wisdom Erae, 2021). Health risks from poor ventilation and pest infestations, inadequate fire safety measures, and security lapses further exacerbate these concerns (Adejimi, 2015; B Chanter & Swallow, 2017; Barrie Chanter & Swallow, 2008; Dzulkipli et al., 2021; Yong & Zailan Sulieman, 2015). From the researcher's perspective, proactively managing these safety risks is crucial. Effective strategies, such as regular safety inspections, improving infrastructure, and enhancing emergency preparedness, are essential not only for preventing accidents and health issues but also for ensuring a secure and conducive learning environment for both students and staff.

Operational Risk (OR)

Operational risks, such as equipment breakdowns and maintenance disruptions, can severely impact school operations, staff productivity, and student learning (Alavi, Abd. Wahab, Muhamad, & Arbab Shirani, 2014; Najeeb, 2024; Tezel, Koskela, & Tzortzopoulos, 2016; Zehra et al., 2024). These risks include issues like poor maintenance, which diminishes job satisfaction and efficiency, and operational inefficiencies such as scheduling conflicts and resource wastage (Mitchell, 1992). Furthermore, stakeholder satisfaction and the school's reputation are at stake. From the researcher's perspective, implementing proactive maintenance strategies, improving scheduling practices, and optimizing resource allocation are essential for managing these operational risks effectively. Such measures not only enhance school efficiency but also preserve stakeholder trust and support.

CONCLUSION

This research effectively identifies and examines the determinant factors of perceived risk in Risk-Based Maintenance Management (RBMM) through a comprehensive Systematic Literature Review (SLR). The review reveals four key determinant factors: safety, performance, operational, and financial risks. Additionally, 20 attributes were identified as Independent Variables (IV), and three attributes as Dependent Variables (DV), contributing to the understanding of perceived risk in maintenance management. The development of a robust Conceptual Model provides a clear framework for analysing these relationships. Future research is recommended to focus on

cross-contextual studies to explore the applicability of these factors across different educational settings, conduct longitudinal analyses to observe changes over time, validate the conceptual model through quantitative methods, and incorporate varied stakeholder perspectives to enrich the understanding of perceived risk. These recommendations aim to refine RBMM practices and enhance the effectiveness of maintenance management in public schools.

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AUTHOR CONTRIBUTIONS

All authors contributed to the idea development, theory formulation, computations, analytical verification, supervision, critical feedback, and manuscript preparation.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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