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The Key Factor Influencing the Implementation of Internet of Things in Facility Management Through Technological-Organisational-Environmental Framework: Trends, Gaps and Future Research

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Abstract: This study explored the current literature on the implementation of the Internet of Things (IoT) in facility management (FM), focusing on key technological, organisational and environmental factors based on the technological-organisational-environmental (TOE) framework. Effective implementation of IoT in FM enhances operational efficiency, cost-effectiveness and sustainability by enabling real-time monitoring, predictive maintenance and optimal resource utilisation. A systematic literature review (SLR) of 28 articles, published from 2014 to 2023, was conducted following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines and thematic analysis was employed to provide a detailed overview of the state of IoT in the FM industry. Articles were identified and extracted from three academic databases: Scopus, ScienceDirect and Google Scholar, for comprehensive coverage of relevant fields. The selected articles met the inclusion criteria set for the research question: What are the factors influencing IoT implementation in FM? The analysis analysed using ATLAS.ti version 9 identified three main themes: technological, organisational and environmental factors influencing IoT implementation in FM. Key findings revealed technological factors such as integration challenges, standardisation issues and data security concerns. Organisational factors like resistance to change, leadership and stakeholder involvement and training needs, while environmental factors, including regulatory compliance, economic feasibility and sustainability considerations, played crucial roles in shaping IoT implementation in FM. These insights provide valuable guidance for researchers, practitioners, stakeholders and policymakers in understanding and addressing the multifaceted aspects of IoT implementation in FM, paving the way for future research and practice.

Keywords: Systematic literature review, Internet of Things, Facility management, Technological-organisational-environmental framework, Technology acceptance model

INTRODUCTION

Internet of Things (IoT) refers to the connectivity of objects to the Internet, enabling them to be monitored, controlled and managed remotely. Additionally, IoT allows surrounding devices to connect and communicate both directly and indirectly. According to Li, Xu and Zhao (2014), the IoT is characterised as a network of interconnected physical devices, each uniquely identifiable and

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capable of collecting and exchanging data. For instance, the IoT encompasses billions of devices, including sensors, cameras, wearables, smartphones and other internet-connected machines found in homes, vehicles and industrial plants, with the number of connected devices increasing rapidly (Dawod et al., 2022). Nowadays, the increasing integration of IoT technologies in facility management (FM) has revolutionised traditional operational paradigms. This transformational shift is characterised by real-time data analytics, enhanced efficiency and enhanced connectivity, offering the facility managers and stakeholders valuable insight into facility performance through advanced technologies. For instance, in the context of commercial buildings, operations involve various systems, including heating, ventilation, air conditioning, lighting and security. This underscores the increasing complexity of FM and the demand for advanced technologies like IoT (Sarkar, 2021).

As buildings and facilities become more connected, the challenges and opportunities associated with IoT implementation in FM have attracted significant scholarly attention. As we understand the diverse challenges and opportunities in IoT implementation for FM, it becomes increasingly clear that certain key factors play a crucial role in ensuring the success of IoT implementation in FM. It is essential to carefully consider these factors for the effective integration of IoT in FM practices. In a previous study by Sidek, Ali and Alkawsi (2022), they emphasised that key factors, such as technical and human factors, need to be addressed to contribute to the successful implementation of IoT in FM. Besides that, Dlesk et al. (2023) also highlighted the importance of systematically considering key factors and challenges to ensure the seamless integration of IoT into FM practices, preventing potential inefficiencies or obstacles during IoT implementation. Moreover, in a study on IoT-heating, ventilation and air conditioning (HVAC) systems in FM by Sanzana et al. (2022), they emphasise the implications of malfunctions in HVAC systems, which can result in significant financial losses for the FM sector due to inadequate consideration of several key factors before implementation. Thus, leveraging insights from previous research and literature reviews, we believe that this study will unveil the key factors influencing the implementation of IoT, particularly within the FM industry.

Objective of Systematic Literature Review

According to Fung, Besser and Poon (2021), the aim of conducting a systematic literature review (SLR) is to offer a thorough and unbiased summary of the existing literature on a particular topic, employing explicit and replicable methods. Therefore, this study aimed to examine the key factors influencing the implementation of IoT within FM by introducing the technology-organisation-environment (TOE) framework as our analytical framework.

Within TOE framework proposed by Tornatzky and Fleischer (1990), three key themes have been identified: technological, organisational and environmental. Under the technological theme, integration challenges, standardisation issues, and data security and privacy concerns are examined. For the organisational factor, sub-themes include resistance to change, leadership and stakeholder involvement, training and skill development, and a lack of IoT knowledge awareness. Meanwhile, the environmental theme addresses regulatory and compliance factors, economic feasibility, sustainability and environmental impact.

Figure 1 provides details of the TOE framework, representing the interplay between these key themes and sub-themes in this SLR study. This thematic study aimed to synthesise existing literature, uncover patterns and identify research gaps to reveal how these key factors shaped the landscape of IoT implementation, particularly in FM.

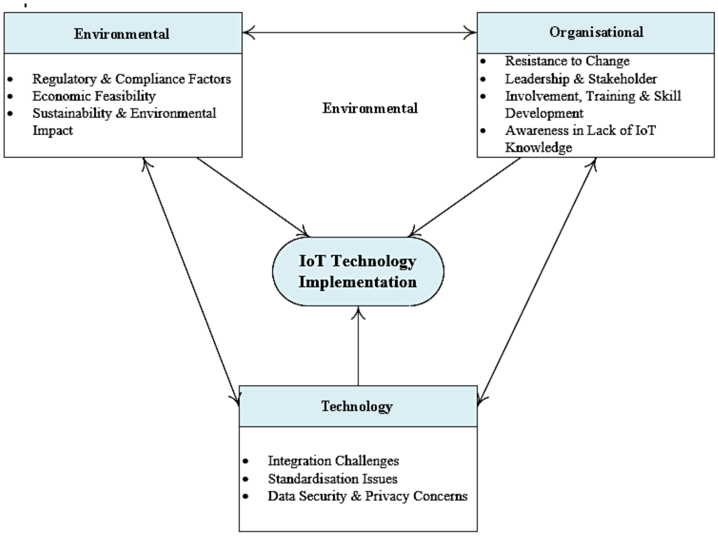

Figure 1. Modified TOE framework

Modified Technological-Organisational-Environmental Framework

The modification of the TOE framework was the outcome of careful consideration to align the framework with the unique challenges and dynamics present in the Malaysian FM context. The variables chosen for each technological, organisational and environmental factor were selected carefully to directly relate to and validate the current issues and practices in FM within Malaysia. As part of this modification, we aimed to ensure that the framework accurately captures and addresses the specific technological challenges, organisational details and environmental considerations that are crucial in FM practices in Malaysia, tailoring it to the landscape of the industry. Therefore, through this customisation of the TOE framework, we ensured an accurate, useful and perfectly aligned framework with the realities and requirements of the Malaysian FM environment.

In the technological field, addressing integration challenges is crucial, given that facilities often operate with existing systems, necessitating the seamless assimilation of IoT. Pimsakul, Samaranayake and Laosirihongthong (2021) further support this by identifying system integration and IoT infrastructure as essential for the overall success of IoT implementation. Their findings emphasise the pivotal role of overcoming integration challenges in implementing IoT in FM. Furthermore, in the context of standardisation issues, they are crucial for device interoperability in FM. For example, Maskuriy et al. (2019) stated that the implementation of IoT aligns with IR 4.0, integrating IoT into manufacturing for intelligent control and monitoring, enhancing efficiency. Standardised protocols ensure seamless communication among interconnected devices, thereby contributing to the success of IR 4.0 in the FM industry. The implementation of the IoT in FM is also influenced by data security and privacy concerns. Generally, organisations that adopt IoT networks may be at risk due to improper authentication of data generated from IoT use cases (Gbadamosi, Hancke and Abu-Mahfouz, 2020). Thus, Nikolić et al. (2020) emphasised in their study that the rise of connected IoT devices in manufacturing facilities emphasises the need for cybersecurity, highlighting the importance of adhering to established security standards and best practices to protect IoT-enabled facilities from potential cyber threats.

For the organisational factor, evaluating resistance to change anticipates challenges in getting stakeholders on board with IoT implementation. Valinejadshoubi et al. (2021) highlighted in their study the challenges policymakers face in achieving expected outcomes from energy-saving policies, including potential resistance to change within the industry. This observation aligns with the pivotal factor of resistance to change in IoT implementation within FM, underscoring the necessity of addressing resistance for a successful implementation. Effective leadership and stakeholder involvement are also crucial factors that significantly influence the success of IoT implementation in FM. Rafsanjani and Ghahramani (2020) emphasise the importance of effective stakeholder management in complex product systems, ensuring collaboration and alignment with stakeholder expectations as a crucial factor in successful initiatives like integrating IoT technologies in FM. Training and skill development are also crucial in determining the success of IoT implementation in FM and should be carefully considered. Moreover, Dosumu and Uwayo (2023) highlighted that insufficient awareness of the benefits is a significant challenge in IoT implementation within the construction industry. Although this finding was specific to the construction industry, it aligns with the broader concern of a general lack of knowledge about IoT. In FM, addressing this knowledge gap is crucial for the successful implementation of IoT solutions.

Considering environmental aspects, understanding regulatory factors is crucial for successful IoT implementation. Schröeder et al. (2020), in their study, highlighted the role of proactive government policies, emphasising their influence on IoT technology evolution in China. This underscores the importance of regulatory and compliance factors, where governmental policies play a pivotal role in shaping the regulatory landscape. In addition, Ali et al. (2023) highlight the importance of factors such as communication, control, automation, efficient business processes, self-configuration and cost savings for the successful implementation of IoT. The acknowledgement of cost savings directly aligns with the critical aspect of economic feasibility in the decision-making process for adopting IoT technology, particularly in the FM sector. Finally, the implementation of IoT in FM holds the potential for a significant impact on sustainability and environmental considerations. Azizi et al. (2020) highlight its use in improving space use efficiency, contributing to environmental sustainability. This aligns with the crucial focus on sustainability and environmental impact in IoT implementation in FM, demonstrating the role of IoT technologies in promoting environmentally sustainable practices. In summary, a holistic approach to TOE factors, supported by relevant citations, provides a comprehensive framework for successful IoT implementation in FM.

METHODOLOGY

To initiate the review process, a literature search and data collection were conducted to gather articles related to IoT technology in FM published between 2014 and 2023. This time frame was chosen to capture the latest developments in IoT technology, as IoT applications began to gain significant momentum in FM from 2014 onwards. Focusing on studies from the past decade enabled the review to present a current perspective on the trends, challenges and advancements in IoT implementation within FM. The review employed three comprehensive search strings across the Scopus, ScienceDirect and Google Scholar databases. To prioritise comprehensive coverage, primary reliance was placed on the Scopus database, which is known for its extensive inclusion of construction, interdisciplinary and journal publications (Solomon, 2013). In addition, it is regarded as the world's largest citation database, with over 18,500 journals. The search was extended to include two additional databases, ScienceDirect and Google Scholar, to ensure a comprehensive and inclusive review of the available literature.

Systematic Review Protocol

The research question for this SLR was formulated using the population-interest-context (PICo) framework. The PICo framework serves as a mnemonic for structuring SLR research questions through qualitative synthesis, aiding in the identification of essential aspects or elements necessary for the formulation of the research question (Lockwood, Munn and Porritt, 2015). The framework has been widely used in qualitative SLRs to effectively define research questions by focusing on the population, phenomenon and context of interest, thereby ensuring a comprehensive and well-structured research question (Stern, Jordan and McArthur, 2014; Munn et al., 2018).

For this study, the research question "What are the key factors influencing IoT implementation in FM?" was formulated and is aligned with the PICo framework. "Population" encompassed professionals involved in FM practices, while "Interest" focused on identifying and examining key factors related to IoT implementation. "Context" involved comparisons across different FM contexts. However, this study primarily focused on the building context, which included the management and maintenance of commercial, residential and institutional buildings. The building context covered aspects such as energy management, security, space optimisation and predictive maintenance. These are critical areas where IoT technologies can significantly enhance efficiency, reduce costs and improve overall facility performance.

Search Strategy

In formulating the search strategy, predefined inclusion criteria for study consideration were outlined in a protocol, adhering to preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines. According to Fossati et al. (2021), PRISMA guidelines uphold rigour and transparency throughout the review process. The initial identification of studies involved searching three databases: Scopus, ScienceDirect and Google Scholar. The search was conducted using the search string, as shown in Table 1. As a result of this process, a total of 698 articles were identified, of which 388 were retrieved from Scopus and the remaining 310 were obtained from ScienceDirect and Google Scholar.

Table 1. Search strings from three academic databases

Database	Search String	Results
Scopus	"Internet of Things" OR "IoT" AND "Facility Management" OR "Facilities Management" OR "FM"	334
	"Internet of Things" OR "IoT" AND "Facility Management" OR "Facilities Management" OR "FM" AND "key factor" OR "challenge"	54
ScienceDirect Google Scholar	"Internet of Things" OR "IoT" AND "Facility Management" OR "Facilities Management" OR "FM" AND "key factor" OR "challenge"	310

Identification and Screening Process

In the first phase of screening, articles were excluded for various reasons, including duplication of articles with 249 duplicates, inaccessibility or lack of full-text availability, classification as document types other than conference proceedings and journal articles (e.g., review paper, report or book), as well as articles in non-English languages. Consequently, a total of 594 articles were excluded based on these criteria, resulting in 104 articles remaining for further comprehensive analysis. In the subsequent screening phase involving the 104 selected articles, the screening process was on identifying relevant content based on the article's title, abstract and keywords. Keyword screening was employed to focus only on the presence of IoT-related keywords. However, the results generated by FM were overly broad. Thus, to conduct a more refined exploration, the findings were categorised into distinct concepts, such as those related to digitalisation in FM (Lee, Irisboev and Ryu, 2021), as illustrated in Table 2. Additionally, only the relevant items pertaining to FM in the context of building and residential buildings were included. This stage resulted in the exclusion of 25 articles, leaving 79 for the subsequent eligibility stage.

Table 2. The concept related to digitalisation in FM

No.	IoT-Digitalisation in FM
1	Building automation systems; IoT sensors; Predictive maintenance; Energy management and efficiency; Smart building technology; Smart home technology; Space management; IoT-building information modelling (BIM); Urban FM; Sustainability; Intelligent building; Smart city; Smart built environment; Smart FM

Source: Lee, Irisboev and Ryu (2021)

Eligibility

The final screening stage narrowed down the 79 articles by excluding articles related to IoT studies in contexts beyond FM, such as healthcare, hospitality, agriculture, construction and education and requiring a discussion of key factors or challenges from at least one of the technological, organisational or environmental perspectives. This step led to the exclusion of 51 articles, resulting in the inclusion of a final set of 28 articles for review in this study. The flow chart for PRISMA2020, as depicted in Figure 2, was generated using an online tool named, Shiny apps. Figure 3 illustrates the generated result of the comprehensive PRISMA2020 flow diagram, detailing the inclusion and exclusion of articles for the overall process (Haddaway et al., 2022).

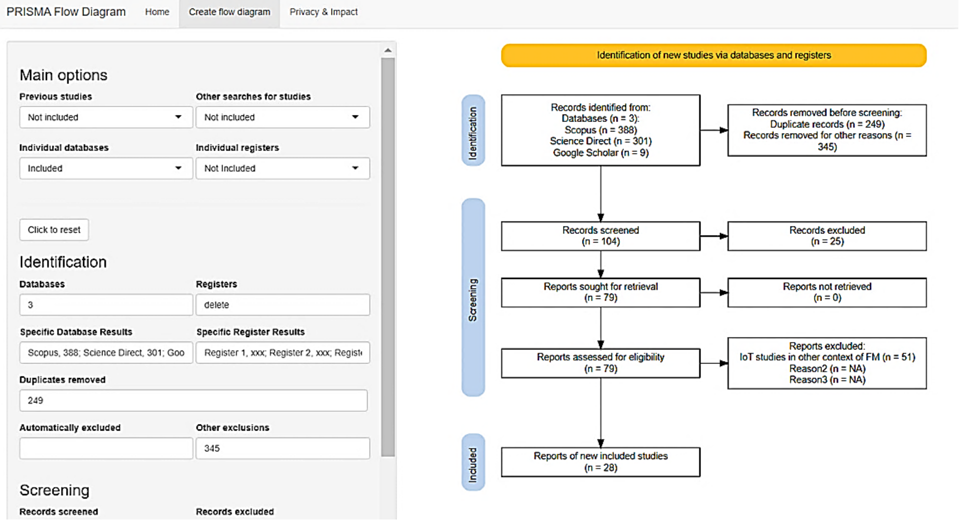

Figure 2. PRISMA2020 flow diagram generated by Shiny apps

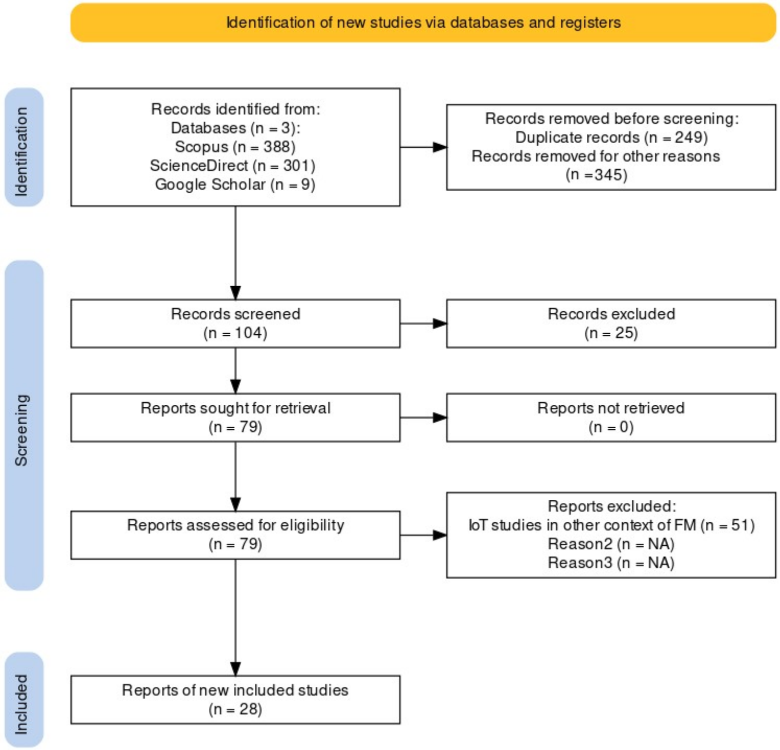

Figure 3. PRISMA2020 flow diagram of inclusion and exclusion for articles

RESULTS AND DISCUSSIONS

Systematic Literature Review Process

In the beginning, all 28 articles in PDF format were imported into ATLAS.ti version 9 and designated as the primary document. In the initial coding round, 10 codes, three main themes and 10 sub-themes were generated, namely: integration challenges, standardisation issues, data security and privacy concerns, resistance to change, leadership and stakeholder involvement, training and skill development, awareness of lack of IoT knowledge, regulatory and compliance factors, economic feasibility and sustainability and environmental impact. Subsequently, guided by TOE framework, the study categorised and organised the codes into three main groups: technological, organisational and environmental, addressing the primary research question of "What are the key factors influencing IoT implementation in FM from 2014 to 2023?"

Quantitative findings were presented in a graphical summary, while qualitative results were thoroughly discussed within each developed theme. Using the ATLAS.ti, a word cloud illustrated the frequency of key factors in the FM industry, as shown in Figure 4. Finally, the SLR results were categorised into quantitative and qualitative findings.

Figure 4. Word cloud generated from 28 articles

Quantitative Finding

As shown in Table 3, the analysis results from ATLAS.ti revealed the diverse selection of journals by researchers for publication. The various fields covered in these publications underscore the credibility of research potential within this topic. All reviewed studies were published in well-established journals and proceedings with indexing, confirming the trustworthiness of the review's results. The data analysis revealed that "Building and environment" and "Sensors" were two of the most popular choices among researchers.

Table 3. Distribution of publications by article source and years

Article Source	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
2022 European Conference on Computing in Construction									1	
35th International Symposium on Automation and Robotics in Construction					1					
Energies									1	
Applied Energy							1			

(*Continued on next page*)

Table 3. *Continued*

Article Source	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Building and Environment				1			1			
Business Process Management Journal					1					
Computers and Electrical Engineering		1								
Construction of Unique Buildings and Structures	1									
Energy and Buildings									1	
IEEE Transactions on Engineering Management							1			
In Advances in Science, Technology and Innovation							1			
International Journal of Advanced Computer Science and Applications							1			
International Journal of Advances in Engineering and Technology					1					
International Journal of Smart Home			1							
International Review of Applied Sciences and Engineering					1					
IOP Conference Series: Earth and Environmental Science						1				
Journal of Engineering Project and Production Management										1
Open Engineering						1				
Procedia Engineering				1						
Proceedings of International Structural Engineering and Construction										1
Progress in Energy and Environment							1			
Renewable and Sustainable Energy Reviews				1						

(*Continued on next page*)

Table 3. *Continued*

Article Source	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Sensors								1	1	
Sustainability							1			
Sustainable Cities and Society								1		

Publication Trends Over the Year

Figure 5 shows the breakdown of the selected articles by year. Most articles were published in 2020, followed in 2014, 2015 and 2016. Over the years, the number of articles related to IoT technology in FM steadily increased, with the year 2020 having a rise compared to the years before 2019. This review illustrated the trends and patterns observed in the selected publications (as shown in Table 4). The qualitative section provides a detailed discussion of the findings within each theme.

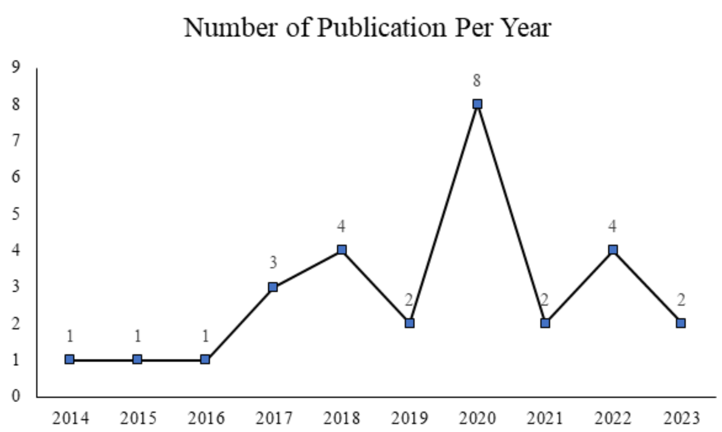

Figure 5. Number of publications per year

Table 4. Thematic mapping

Source	Technological			Organisational				Environmental		
	1	2	3	4	5	6	7	8	9	10
Brad and Murar (2014)	●	●	●						●	●
Collotta and Pau (2015)	●	●	●							
Ahn (2016)	●		●							

(*Continued on next page*)

Table 4. *Continued*

Source	Technological			Organisational				Environmental		
	1	2	3	4	5	6	7	8	9	10
Ford et al. (2017)	●		●							
Araszkiewicz (2017)	●	●	●	●	●	●	●	●	●	●
Amini, Feizi-Derakhshi and Fotuhi-Firuzabad (2017)	●	●	●							
Pasek and Sojkova (2018)	●	●	●	●	●	●	●	●	●	●
Chung et al. (2018)	●	●	●	●	●	●			●	
Alkhayatt et al. (2018)	●	●	●						●	●
Dang and Trotskii (2019)	●	●	●	●	●	●	●	●	●	●
Talamo et al. (2019)				●	●	●	●	●	●	●
Codinhoto, Fabricio and Fialho (2020)	●	●	●	●	●	●	●	●	●	●
Konanahalli, Marinelli and Oyedele (2020)	●	●	●	●	●	●	●	●	●	●
Azizi et al. (2020)	●	●	●	●	●	●	●			
Atta and Talamo (2020)	●	●		●	●	●	●	●	●	●
Chew et al. (2020)	●	●	●	●	●	●	●	●	●	●
Wang et al. (2020)	●	●	●			●	●			
Raendran et al. (2020)	●	●	●	●	●	●	●	●	●	●
Rafsanjani, Ghahramani and Nabizadeh (2020)	●	●	●	●	●	●	●	●	●	●
Valinejadshoubi et al. (2021)	●	●		●			●			
Bouabdallaoui et al. (2021)	●	●	●	●	●	●	●	●	●	●
Al-Obaidi et al. (2022)	●	●	●	●	●	●	●	●	●	●
Kanna, Lachguer and Yaagoubi (2022)	●	●		●	●	●	●	●	●	●
Pellegrini et al. (2022)	●	●	●	●	●	●	●	●	●	●
Sidek, Ali and Alkawsi (2022)	●	●	●	●	●	●	●	●	●	●
Anathan, Yusof and Rahman (2023)	●	●	●	●	●	●	●	●	●	●
Piantanida et al. (2023)								●	●	●

PUBLICATION TRENDS BY COUNTRY AND CONTINENT

The studies on IoT technology in FM were conducted in various countries, as depicted in Figure 6. Malaysian researchers showed a keen interest in this area (4), followed by the United Kingdom (3). Canada, Italy, the Netherlands, South Korea, Switzerland and the USA each produced two studies. Australia, China, Croatia, the Czech Republic, France, Greece, Morocco, Romania and Sweden each contributed one study. Furthermore, among continents, Europe published the most studies related to IoT in FM (60.7%), followed by Asia (25.0%), South America (7.1%) and Africa (3.6%) and Australia (3.6%), as shown in Figure 7.

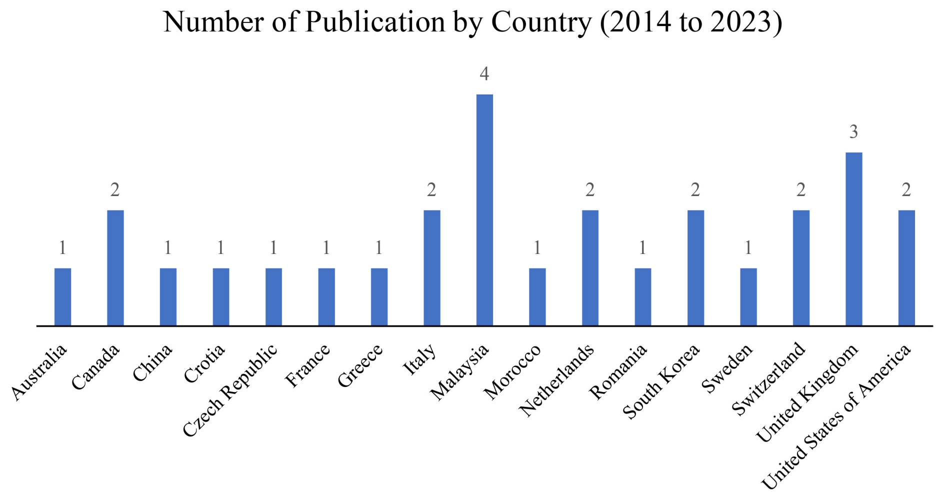

Figure 6. Distribution of the number of publications from years 2014 to 2023

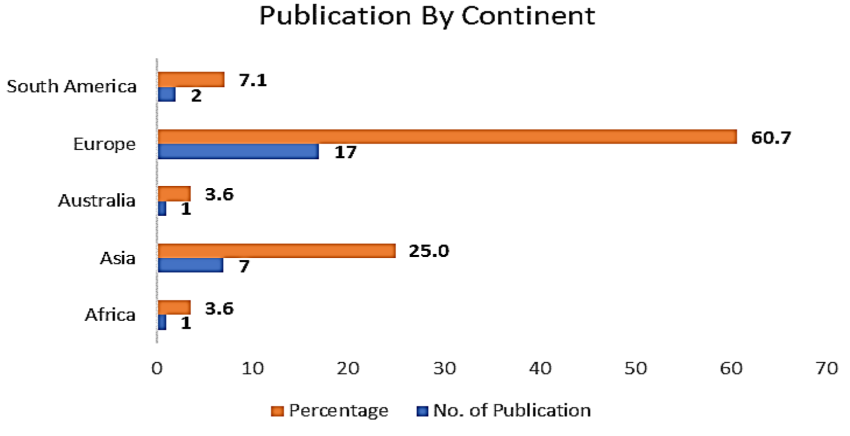

Figure 7. Publication by continent from years 2014 to 2023

Qualitative Findings

The review's qualitative findings provided a detailed insight into the identified themes aimed at addressing the research question mentioned earlier. Through an examination and analysis of the articles, three main themes were recognised: technological, organisational and environmental. This SLR found interconnections and mutual support across the articles. Some articles covered multiple themes, showing how the topics discussed were related. To comprehensively respond to the research question, the findings for each theme were individually explored and presented in the following sections. An overall visual representation is presented in Figure 8.

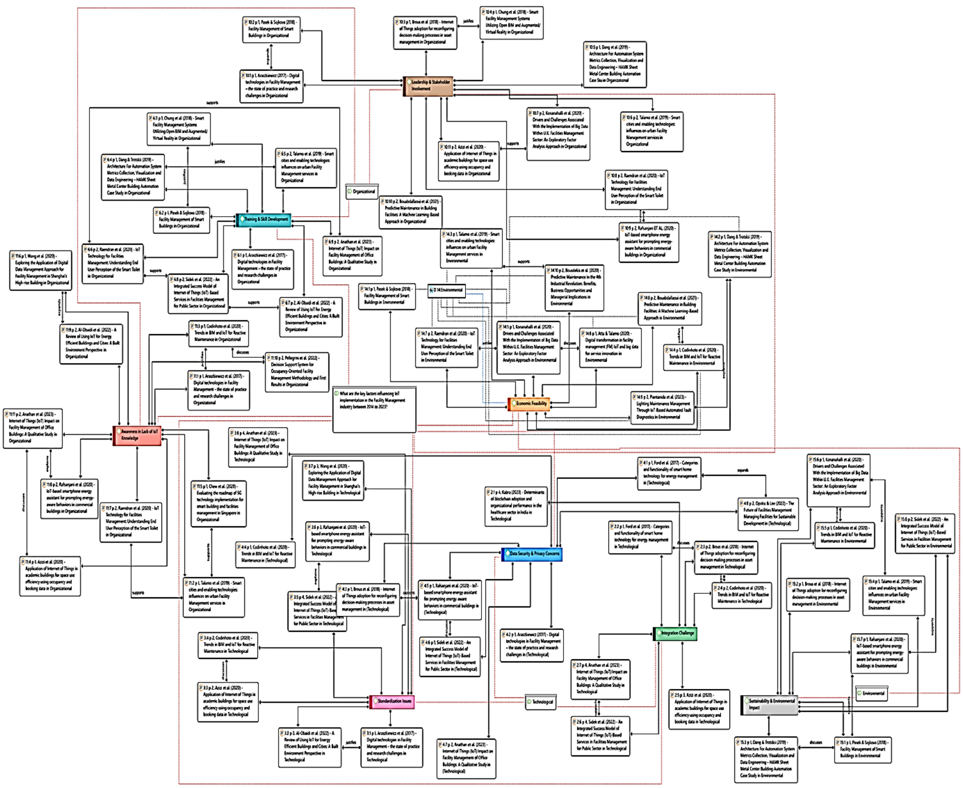

Figure 8. Overall view of selected articles between 2014 and 2023

Technological: Integration Challenges

In the context of IoT implementation in the FM industry, technological compatibility emerged as a crucial factor influencing its successful implementation. Generally, compatibility issues arose when different systems or devices were unable to work together or operate concurrently due to differences in standards, design and specifications (Kabra, 2023). In the study conducted by Ahn (2016) regarding the digital contents IoT system for cleaning FM, a challenge was observed in integrating various components, including the web server, middle server and mobile devices, aiming to ensure smooth communication and functionality. Similarly, a study by Ford et al. (2017) focusing on IoT-smart home systems indicated that integrating IoT devices into existing home systems faced obstacles due to different communication protocols and data formats. This created challenges in achieving interoperability with the established home infrastructure.

Brous, Janssen and Herder (2018) demonstrated the complexity of integrating data from multiple IoT sources, involving the alignment of complex data structures, semantics and ontology. This process encompasses issues related to interoperability and convergence. Codinhoto, Fabricio and Fialho (2020) supported this statement, emphasising that integrating IoT technology or systems with existing building systems and processes is challenging due to system complexity and interoperability needs. Furthermore, the integration of IoT devices posed challenges due to the differences in hardware, software and communication protocols, potentially causing issues with data compatibility and interoperability (Azizi et al., 2020). Moreover, in their study on IoT-based services systems in FM, Sidek, Ali and Alkawsi (2022) highlighted that integrating IoT into existing systems, especially with older systems, can pose compatibility issues, necessitating additional resources to ensure smooth integration. In line with this, Anathan, Yusof and Rahman (2023) also emphasised the difficulties in integration challenges that may arise when replacing new technology in the existing system. In their study on the impact of IoT on FM, they underscored that integrating IoT technologies into FM systems presents challenges, particularly compatibility issues in the current systems in use. Figure 9 depicts the network view on the theme of "Technological: Integration challenge".

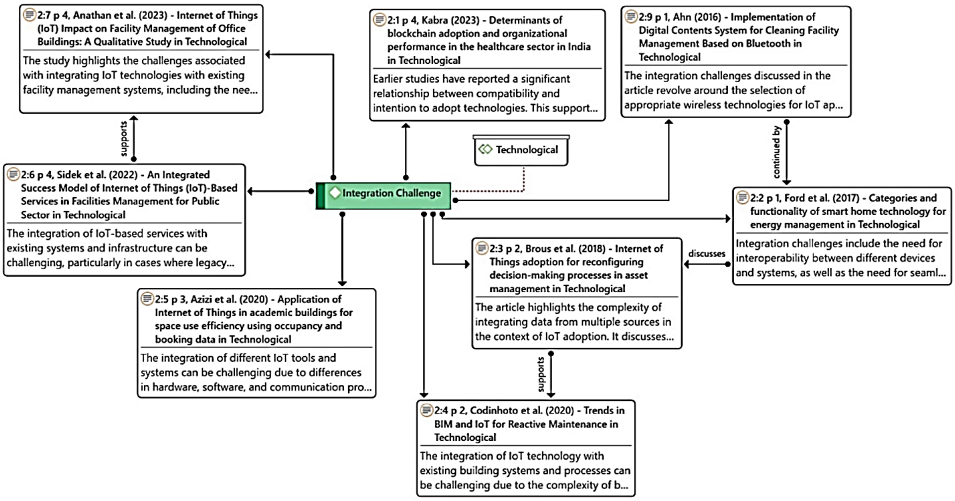

Figure 9. Network view of the articles on "Technological: Integration challenge"

Technological: Standardisation Issues

Standardisation plays a pivotal role in the successful implementation of IoT in meeting FM needs. Araszkiewicz (2017), in his study on digital technology practices in FM, emphasises the importance of standardising digital technologies to ensure efficient data exchange between systems and platforms, thereby guaranteeing seamless integration and interoperability. Al-Obaidi et al. (2022) concurred with this perspective, emphasising the significance of standardisation in digital technologies within the built environment. In their study, they emphasised the necessity of standardisation in IoT technologies for buildings and cities, stressing the importance of uniformity in establishing networks and exchanging data. The absence of standardisation in IoT technology implementation may negatively affect organisations. For instance, the lack of common protocols and standards can result in compatibility issues, security vulnerabilities and concerns related to data privacy (Brad et al., 2014). Besides that, the lack of standardisation in IoT technologies might also impede compatibility and interoperability among systems and devices (Azizi et al., 2020). Additionally, Codinhoto, Fabricio and Fialho (2020) highlighted that the absence of standardisation in IoT technology can also hinder effective integration and scalability across different buildings or facilities. Furthermore, the lack of standardisation in IoT-based services, as noted by Sidek, Ali and Alkawsi (2022), made data management and analysis challenging. For instance, standardisation challenges may arise in terms of data formats, communication protocols and interoperability with the use of various IoT devices and sensors (Rafsanjani, Ghahramani and Nabizadeh, 2020). In the global landscape of FM, adapting to international systems was challenging. This is particularly evident in the study by Wang et al. (2020), where foreign FM systems encountered standardisation challenges due to cultural and architectural differences. In conclusion, Anathan, Yusof and Rahman (2023) stressed the critical importance of considering the lack of standardisation in IoT technologies as it hinders implementation and interoperability. Therefore, recognising this key factor is crucial for effective planning and successful implementation. Figure 10 displays the network view on the theme of "Technological: Standardisation issues".

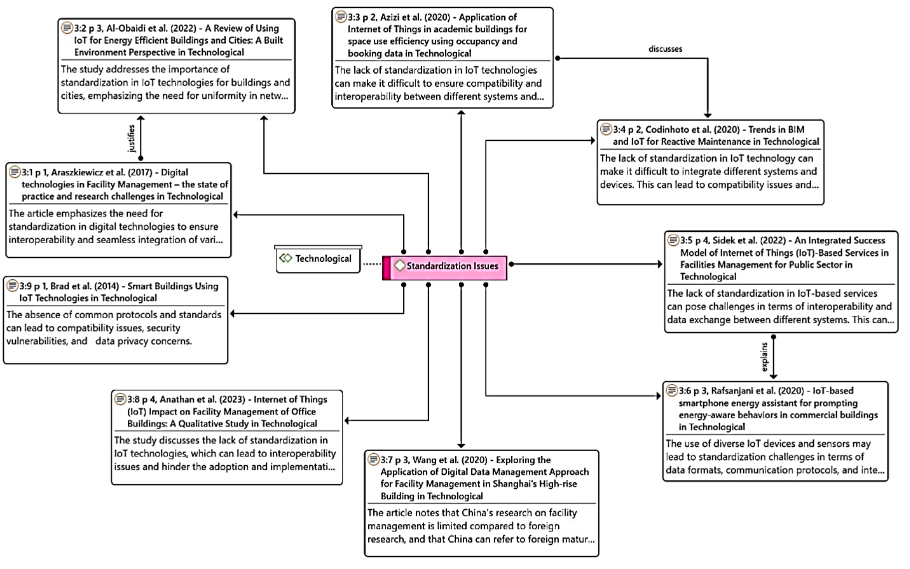

Figure 10. Network view of the articles on the "Technological: Standardisation issues"

Technological: Data Security and Privacy Concerns

Numerous studies illustrated the importance of data security and privacy in the FM industry. Opoku and Lee (2022) underscored the pivotal role of facility managers in adopting sustainability principles, a task that inherently involves ensuring data security and privacy within the facilities they manage. In general, the risks related to data security and privacy encompass unauthorised access to personal information, along with the necessity to securely transmit and store data (Ford et al., 2017). Collotta and Pau (2015), in their study on power management in smart home systems, underscored the importance of addressing data security and privacy concerns when integrating smart devices into home automation. They also emphasised the implementation of authentication, encryption and potential end-to-end security measures for safeguarding sensitive data. Besides that, according to Araszkiewicz (2017), the utilisation of digital technologies in FM increased concerns about the security and privacy of data collected from sensors or devices in building management systems. The emphasis was on the need to protect sensitive information and ensure occupant privacy while implementing IoT systems. Moreover, Codinhoto, Fabricio and Fialho (2020) emphasised the shared concerns that data security and privacy were critical considerations when employing IoT technology for building maintenance or FM. This necessitated building owners and facility managers to ensure the protection of sensitive data and compliance with privacy laws and regulations. Furthermore, Brous, Janssen and Herder (2018) highlighted that, as part of the data collection process involving IoT devices or sensors, the sensitive nature of the information gathered, including location data from smartphones, underscored the importance of ensuring compliance with privacy and security regulations. Rafsanjani, Ghahramani and Nabizadeh (2020), in their study on an IoT-based smartphone energy assistant system in commercial buildings, acknowledged the potential data security and privacy issues linked to IoT-based systems. This was especially relevant in the context of collecting and analysing personal energy-usage data from individual occupants, further supporting concerns raised about data security and privacy in the earlier statement. In addition, Sidek, Ali and Alkawsi (2022) highlighted that IoT-based FM services involving the collection and processing of sensitive data pose security and privacy risks, including the potential for data breaches and unauthorised access. To conclude, IoT-based FM systems require robust security systems to ensure data security and privacy (Anathan, Yusof and Rahman, 2023). This underscores the critical role of prioritising data security and privacy considerations for the successful implementation of IoT in the FM industry. Figure 11 illustrates the network view of “Technological: Data security and privacy concerns”.

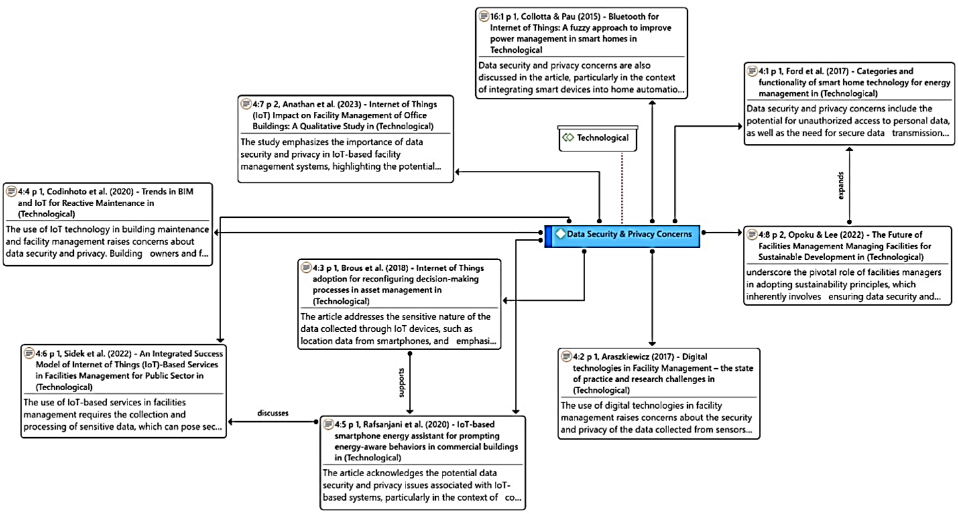

Figure 11. Network view of the articles on the “Technological: Data security and privacy concerns”

Organisational: Resistance to Change

The implementation of new digital technologies in organisations often encountered common challenges, such as resistance to change among the stakeholders. Araszkiewicz (2017) found resistance to be a significant factor in fostering a culture of innovation and adaptation. In this context, the importance of involving stakeholders in the planning and implementation processes was emphasised (Dang and Trotskii, 2019). Talamo et al. (2019) found stakeholders, including employees and decision-makers, hesitated to change existing methods and processes currently employed for FM services. Rafsanjani, Ghahramani and Nabizadeh (2020) also emphasised the potential resistance to change among building occupants and stakeholders when introducing IoT-based energy management systems into their current practices. According to Al-Obaidi et al. (2022), resistance arose from concerns with the unfamiliarity of IoT systems and the necessity for organisational change management strategies. Accordingly, Kanna, Lachguer and Yaagoubi (2022) emphasised the need for effective change management strategies to address resistance and ensure the successful implementation of new technologies. Besides that, Pasek and Sojkova (2018) demonstrated the importance of effective change management strategies when adopting new technologies and processes to meet resistance from employees and stakeholders.

In summary, resistance to change among employees within an organisation has to be overcome to significantly impact the successful implementation of IoT technology, particularly in the FM industry. In line with the study by Sidek, Ali and Alkawsi (2022), implementing IoT-based services can bring about changes in work routines and processes, potentially encountering resistance from employees. Furthermore, organisational culture and existing practices presented barriers to the implementation of new technologies, including IoT (Anathan, Yusof and Rahman, 2023). Consequently, this resistance led to challenges in adopting and implementing the technology. Figure 12 presents the network view on "Organisational: Resistance to change."

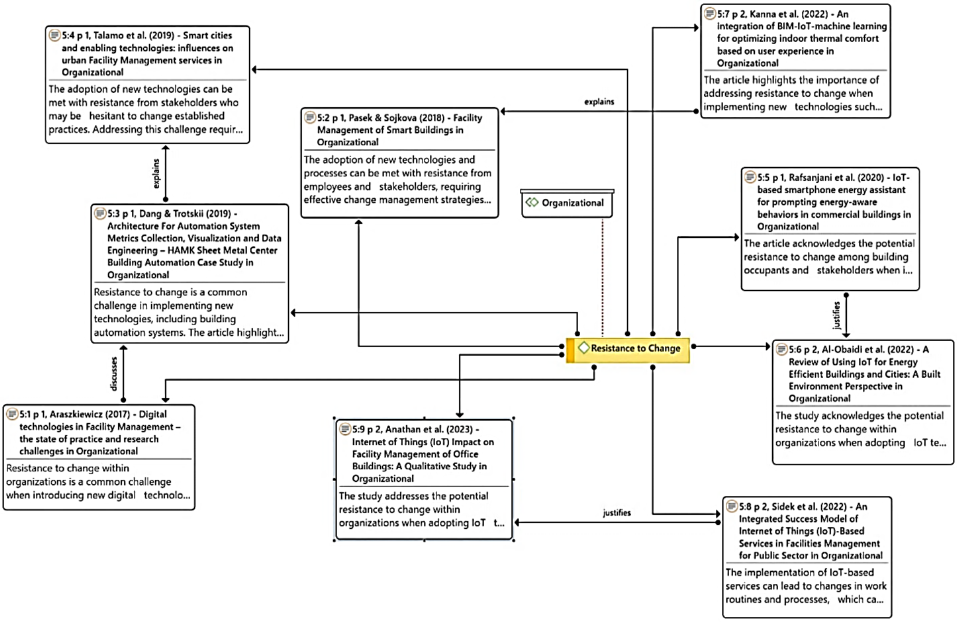

Figure 12. Network view of the articles on "Organisational: Resistance to change"

Organisational: Leadership and Stakeholder Involvement

In the FM industry, effective leadership and stakeholder involvement are crucial for successfully integrating digital technologies, particularly IoT technology. According to Araszkiewicz (2017), leadership support and engaging stakeholders were crucial to facilitate the implementation of new technologies into organisational processes. Similarly, Pasek and Sojkova (2018) emphasised the significance of clear communication, collaboration and goal alignment for managing smart building technologies. Based on all of these perspectives, it is clear that strong stakeholder involvement and leadership support are necessary for the digital technologies transition in FM. In accordance with the study by Konanahalli, Marinelli and Oyedele (2020), the success of digital technologies, such as Big Data and IoT initiatives, depended on the involvement of stakeholders and leadership. Supporting this idea, Azizi et al. (2020) agreed that the success of implementing IoT depended on the involvement of key stakeholders, including leadership and facility managers, in the study on building space.

Brous, Janssen and Herder (2018) pointed out the need for leadership to drive the process and involve stakeholders, addressing their concerns in IoT implementation. Dang et al. (2019) underscored collaboration, effective communication and a common objective to guarantee the system's success.

Chung et al. (2018) demonstrated the importance of leadership and stakeholder engagement in implementing new technologies, such as smart FM, that were based on IoT integration. Rafsanjani, Ghahramani and Nabizadeh (2020), in their study on energy management in commercial buildings, emphasised the crucial necessity of active stakeholder participation and leadership support in promoting the implementation of energy-efficient behaviours. Aligned with this, a study on the IoT-based smart toilet system conducted by Raendran et al. (2020) highlighted the active involvement of stakeholders and effective leadership to address concerns and gain support. In addition, Bouabdallaoui et al. (2021) emphasised that stakeholders, such as facility managers and maintenance staff, must be actively involved and provide leadership support to ensure that the predictive maintenance approach aligns with organisational objectives and promotes the implementation of new technologies in the context of building maintenance. Stakeholder involvement and effective leadership were also essential for the successful implementation of IoT solutions in urban environments (Talamo et al., 2019). In conclusion, the successful implementation of IoT relies on effective leadership and stakeholder engagement. Figure 13 illustrates the network view of the "Organisational: Leadership and stakeholder involvement," generated by the software ATLAS.ti.

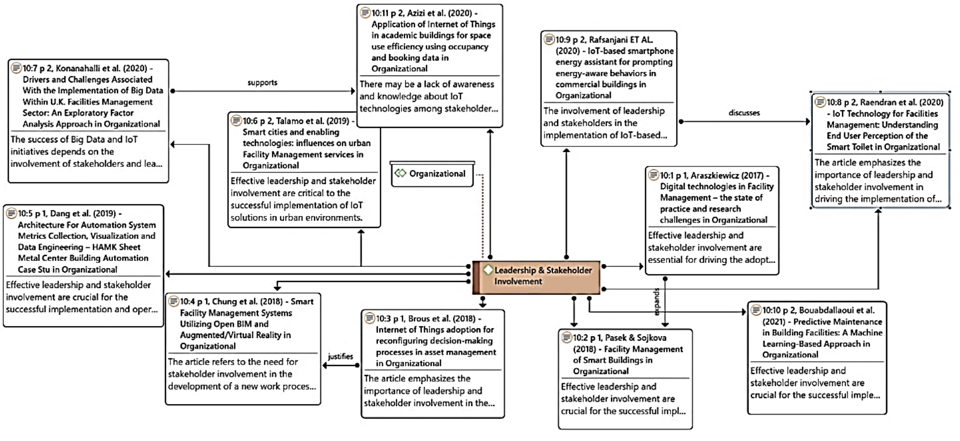

Figure 13. Network view of the articles on the "Organisational: Leadership and stakeholder involvement"

Organisational: Training and Skill Development

Training and skill development are crucial to the effective implementation of IoT technology and can be characterised as one of the most significant factors in its implementation. Acquiring new skills is crucial when adopting new technologies, emphasising the essential role of training programmes for employees and stakeholders to gain the required competencies (Pasek and Sojkova, 2018). The study by Chung et al. (2018) on the smart FM system indicated that training and skill development among workers were necessary for utilising new technologies such as augmented reality (AR) and BIM in maintenance work. This emphasises the significance of skill development and training for the successful implementation of smart FM. Besides that, training programmes were essential for providing FM professionals with the skills and knowledge they needed to effectively implement IoT technology (Anathan, Yusof and Rahman, 2023). Moreover, training programmes played a key role in equipping employees with the knowledge and capabilities for effective utilisation, highlighting that specific skills were needed for the successful implementation of IoT technology in the FM industry (Raendran et al., 2020). Similarly, Sidek, Ali and Alkawsi (2020) agreed that the implementation of IoT-based services required personnel training in data management, analysis and the application of technology. Supporting this idea, Al-Obaidi et al. (2022), in their study on residential buildings, emphasised the need for training and skill development for workers involved in the installation and maintenance of IoT systems in the built environment.

Shifting the focus to the importance of skilled workers, it was essential to have skilled workers and experts in the field to manage or operate sophisticated and new technologies. According to Araszkiewicz (2017), competent personnel and skilled workers were crucial for technological advances to be employed successfully, as well as training programmes that helped them to adapt and maximise their advantages. Besides that, implementing IoT technology required specialised skills, underscoring the need for training opportunities to achieve successful implementation (Talamo et al., 2019). Similarly, Dang and Trotskii (2019) addressed the need for specialised expertise and appropriate training to ensure workers have the competence required for system operation and maintenance of IoT-automation systems. Figure 14 outlines the network view of the research articles, categorised under “Organisational: Training and skill development”.

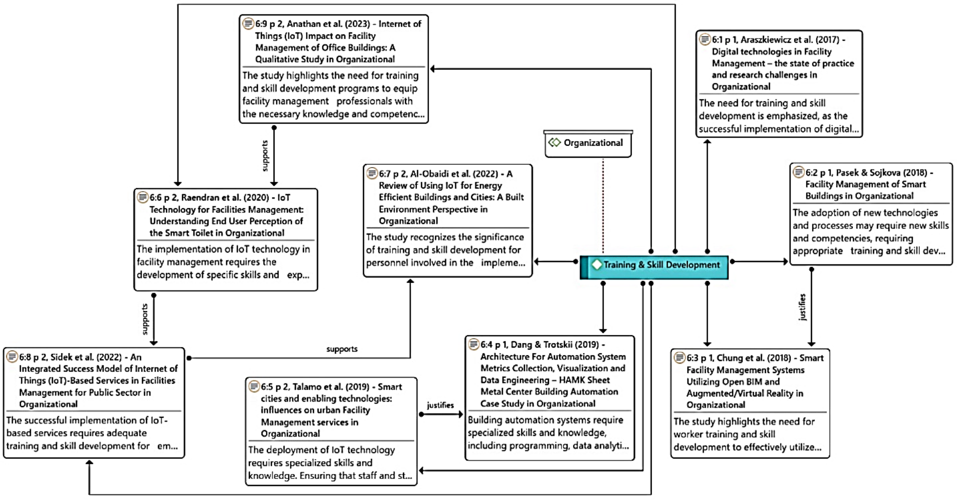

Figure 14. Network view of the articles on the "Organisational: Training and skill development"

Organisational: Awareness of Lack of IoT Knowledge

The implementation of IoT in FM is significantly influenced by the awareness of IoT knowledge within organisations. This statement is proved by Araszkiewicz (2017), who found a limited understanding and awareness of IoT technologies among FM professionals. Similarly, personnel such as the owners of buildings, facility managers and other stakeholders were unaware of IoT technology (Codinhoto, Fabricio and Fialho, 2020). Consequently, the limited awareness and knowledge about IoT technologies and their potential benefits hindered the implementation of IoT technology, particularly in sensor networks (Pellegrini et al., 2022). A significant lack of awareness and knowledge of IoT technologies was identified among FM professionals. FM operators needed tools and strategies to help them choose and implement IoT technologies, as well as address knowledge gaps and awareness issues regarding IoT technologies within the FM sector (Azizi et al., 2020). Thus, to successfully integrate IoT into FM practices within office buildings, Anathan, Yusof and Rahman (2023) emphasised the imperative need to address this gap by raising awareness and providing educational resources to building occupants and stakeholders to bridge the knowledge gap and promote understanding of IoT technologies (Rafsanjani, Ghahramani and Nabizadeh, 2020). Overcoming challenges related to IoT technology required raising awareness by providing education and training opportunities for stakeholders (Talamo et al., 2019). In accordance with Chew et al. (2020), increasing awareness and understanding of IoT technologies were essential for successful implementation. Moreover, Raendran et al. (2020) also pointed out in their study that raising awareness among organisational members of the lack of knowledge associated with the IoT was crucial for fostering a supportive and knowledgeable environment among them.

In conclusion, research on FM emphasised the need for awareness and understanding of IoT knowledge due to the rapid development of information technologies. (Wang et al., 2020). Accordingly, Al-Obaidi et al. (2022) emphasised the need for awareness and educational initiatives to bridge the knowledge gap and promote understanding of IoT technologies and their potential applications among professionals, particularly in the built environment. Figure 15 unveils the network view of research articles, with each article categorised under "Organisational: Awareness in lack of IoT knowledge".

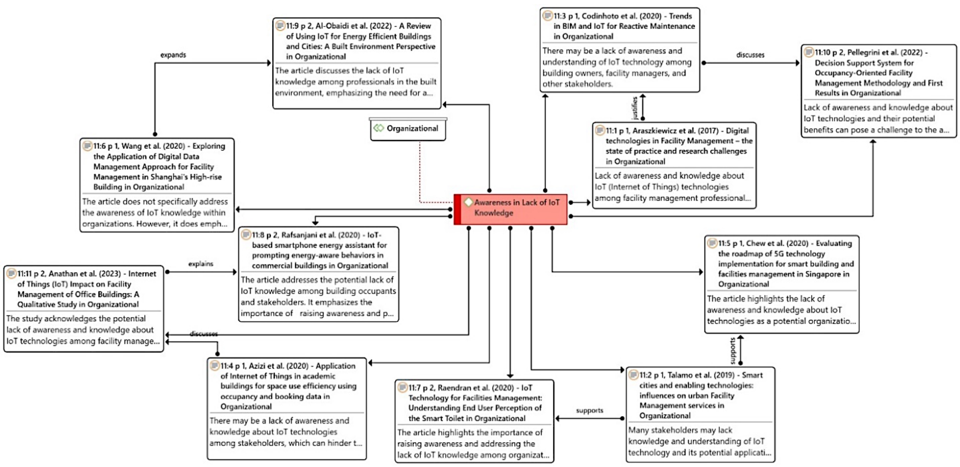

Figure 15. Network view of the articles on "Organisational: Awareness in lack of IoT knowledge"

Environmental: Regulatory and Compliance Factors

Regulatory and compliance factors were critical considerations in the implementation of IoT technologies for FM (Araszkiewicz, 2017). According to Amini, Feizi-Derakhshi and Fotuhi-Firuzabad (2017), the implementation of IoT-based energy management systems was significantly influenced by regulatory and compliance factors, with regulations concerning energy efficiency and renewable energy. For instance, Dang and Trotskii (2019) stated in their study that FM, particularly in building automation systems, must comply with regulations and standards for energy efficiency and environmental standards to achieve occupant safety. Additionally, within the context of building maintenance, IoT implementation should not only align with but also adhere to environmental sustainability, energy efficiency and data privacy regulations and standards (Codinhoto, Fabricio and Fialho, 2020). In another discussion justifying this statement, Talamo et al. (2019) highlighted that the implementation of IoT technology in urban environments must align with the necessary regulations and standards related to environmental protection, energy efficiency and sustainability. The emphasis on compliance was imperative to mitigate the environmental impact associated with urban FM services. Furthermore, Al-Obaidi et al. (2022) stated the importance of regulatory and compliance factors in the implementation of IoT in the built environment. The introduction of the FM Systems Certification Scheme by SIRIM QAS International Sdn. Bhd. in 2019, notably (ISO) 41001:2018, aligns with the emphasis on adherence to regulatory requirements and standards governing environmental sustainability and energy efficiency in buildings and cities. This certification benefits the workforce such as enhanced safety, health and productivity, improved efficiency and effectiveness in facilities, positions industry players for the fourth industrial revolution (IR 4.0) and manages overall organisational cost improvements (Raendran et al., 2020). The network view of research articles categorised under "Environmental: Regulatory and compliance factors", is presented in Figure 16.

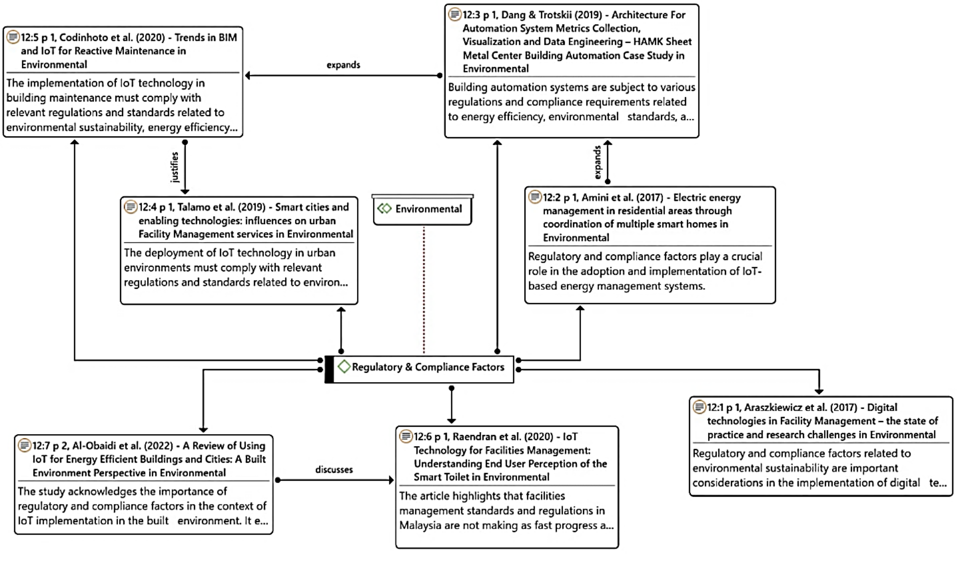

Figure 16. Network view of the articles on "Environmental: Regulatory and compliance factors"

Environmental: Economic Feasibility

The implementation of IoT-based solutions, particularly in building facilities, had gained significant attention in recent years due to its potential to improve FM practices, where economic feasibility is recognised as a key factor influencing the implementation of IoT technology. Alkhayatt and Hagem (2018), in their study on IoT smart home systems, highlighted the potential of these systems to decrease energy consumption and costs, rendering them economically feasible for homeowners. The economic feasibility of IoT solutions was crucial for the deployment of smart urban FM services, ensuring cost-effectiveness and a positive return on investment for long-term sustainability (Talamo et al., 2019). Bousdekis, Apostolou and Mentzas (2020) in their study emphasised the significance of assessing the costs associated with deploying IoT-based services and evaluating potential return on investment and long-term cost savings. Konanahalli, Marinelli and Oyedele (2020) highlighted the importance of cost evaluation and return on investment of Big Data as well as IoT technologies to guarantee economic feasibility. Raendran et al. (2020) further stated that the economic feasibility of IoT-based systems, such as the smart toilet, must be evaluated in terms of their initial investment, operational costs and potential cost savings. In addition, Atta and Talamo (2019) discussed the potential benefits of IoT technology in FM, but cautioned about the significance of initial investments and economic implications.

Furthermore, in the concept of preventive maintenance in FM, IoT technology was considered in terms of potential long-term cost savings from improved maintenance efficiency and energy management (Codinhoto, Fabricio and Fialho, 2020). For instance, a study done by Bouabdallaoui et al. (2021) noted that predictive maintenance must be evaluated economically, balancing implementation costs against potential benefits like reduced maintenance costs and improved energy efficiency. Moreover, cost analysis is also a crucial component of economic feasibility that needs consideration for the successful implementation of IoT technology. Piantanida et al. (2023), in their study on IoT-based monitoring systems for lighting maintenance, indicated that the economic feasibility of implementing an IoT system requires careful consideration due to potential investments in hardware, software and personnel. For instance, this includes the assessment of the cost-effectiveness of IoT systems, considering factors such as energy savings, operational efficiency and long-term maintenance costs (Dang and Trotskii, 2019). Finally, a study by Pasek and Sojkova (2018) emphasised that technology implementation necessitated a significant investment and careful cost-benefit analysis to ensure economic feasibility and a return on investment in smart buildings. Figure 17 presents a visual representation of the network view for research articles, all categorised under “Environmental: Economic feasibility”.

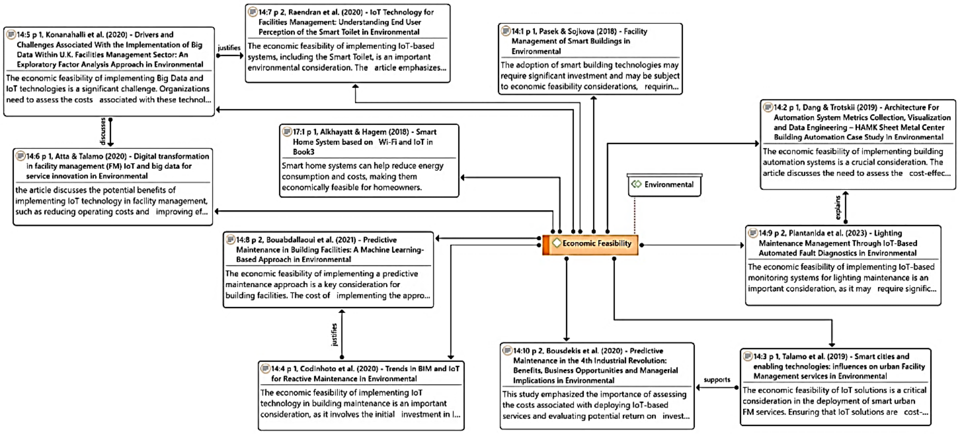

Figure 17. Network view of the articles on "Environmental: Economic feasibility"

Environmental: Sustainability and Environmental Impact

In the landscape of FM, incorporating key environmental factors was crucial in shaping and influencing the effective integration of IoT technology within the FM framework. To improve energy efficiency and reduce environmental impact, Konanahalli, Marinelli and Oyedele (2020) emphasised incorporating sustainability and environmental impact considerations into the implementation of IoT technologies. Talamo et al. (2019) highlighted the implementation of IoT technology in FM services on the environment, requiring a sustainable design and deployment approach. Consequently, it highlighted the importance of integrating sustainability and environmental impact considerations into the implementation of IoT technologies, providing opportunities for improved energy efficiency. In line with this, Codinhoto, Fabricio and Fialho (2020) emphasised that energy usage could be optimised, reducing waste and contributing to sustainability, particularly in building maintenance, through the successful implementation of IoT technology.

Moreover, there was a need for organisations to assess the sustainability and environmental impact of IoT implementation and incorporate these considerations into their decision-making processes (Brous, Janssen and Herder, 2018). For example, the study on smart buildings in FM by Pasek and Sojkova (2018) highlighted that technologies impacted sustainability and the environment, requiring consideration of several factors, such as energy efficiency and carbon footprint. Dang and Trotskii (2019) further discuss this, analysing that building automation systems play a significant role in promoting sustainability and reducing environmental impact by optimising energy usage and reducing carbon emissions. Besides that, this study was expanded and supported by Rafsanjani, Ghahramani and Nabizadeh (2020), who emphasised the need for sustainable and environmentally responsible energy management practices, particularly in commercial buildings. Similarly, supporting this idea, the study by Sidek, Ali and Alkawsi (2022) stated that IoT-based services should consider sustainability and environmental impact, including energy consumption, waste management and overall impact on the environment. Figure 18 provides a graphical representation of the network view for research articles classified under "Environmental: Sustainability and environmental impact".

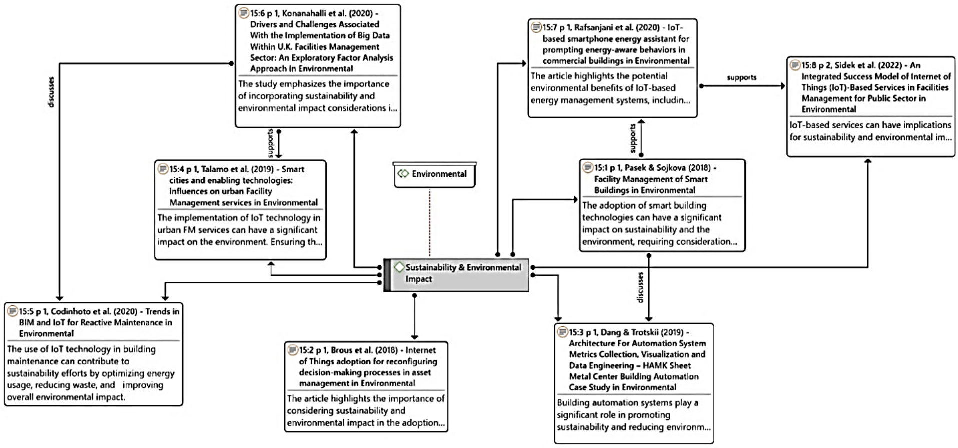

Figure 18. Network view of the articles on "Environmental: Sustainability and environmental impact"

CONCLUSIONS

In conclusion, this SLR examined IoT implementation in FM using the TOE framework. The analysis explored key factors in technology organisation and the environment to reveal significant themes. The technological aspect addressed integration challenges, standardisation issues and concerns about data security and privacy. Organisational considerations included resistance to change, leadership and stakeholder involvement, training, skill development and awareness of IoT knowledge gaps. Meanwhile, the environmental theme explored regulatory compliance, economic feasibility, sustainability and environmental impact.

However, despite these valuable insights, there are notable gaps in existing literature. Most reviewed studies focused on specific aspects. Therefore, there is a need for more comprehensive studies that bridge and link the technological, organisational and environmental dimensions. Although these focused studies contributed to a deeper understanding of these factors in the context of IoT implementation in FM, there was a gap in understanding how they were related to one another. Recognising this identified gap, there is a need for more comprehensive and integrated investigations that bridge and link these three key factors: technological, organisational and environmental perspectives. Therefore, future research should aim to provide a holistic understanding of the interplay and interdependence between technological advancements, organisational structures and environmental considerations in the implementation of IoT in FM.

Furthermore, there has been insufficient exploration of factors that could act as moderators in the relationship between key technological, organisational and environmental factors and the successful implementation of IoT in FM. A “moderator” is defined as a variable that influences the strength or direction of the relationship between other variables (Baron and Kenny, 1986). Thus, factors such as organisational culture, leadership styles and technological readiness are moderators that might impact how strongly these key factors affect IoT implementation outcomes. Accordingly, a thorough investigation of these potential moderators is necessary to achieve a more comprehensive understanding of the contextual factors affecting IoT implementation in FM.

IMPLICATIONS FOR FUTURE RESEARCH

In addition to the identified gaps in the current literature, it is essential to recognise the significance of these findings for future research initiatives, particularly those framed within any models related to technology acceptance and implementation, such as the most widely used model, the technology acceptance model (TAM).

Reviewed studies laid the foundation for future research through the exploration of the complexities of technological, organisational and environmental factors that might influence the implementation of IoT in FM. As a result, these findings provide valuable groundwork for a TAM-focused investigation into user perceptions, attitudes and behavioural intentions regarding IoT technologies in the FM sector. Therefore, integrating the insights from the TOE framework with TAM enables future studies to examine how end-users, stakeholders and decision-makers perceive and interact with IoT solutions within FM organisations. Accordingly, the flexibility of TOE framework allows seamless integration with other models, such as TAM, with the aim of providing a comprehensive understanding of the implementation of new technologies (Ali et al., 2020). In addition to enhancing understanding of the acceptance and implementation processes, this holistic approach will also shed light on the factors that directly affect individual willingness to adopt IoT technologies. Furthermore, within the context of the TAM framework, the synthesised knowledge from the current thematic review provides a foundation for future research, informing the formulation of research questions, hypotheses and methodological approaches. Finally, leveraging these insights and capitalising on advancements in the field of IoT in FM will allow us to develop more comprehensive models or frameworks and then bridge the gap between technology implementation theories and the feasibility of implementing IoT in the practical FM sector.

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REFERENCES

Ahn, B.T. (2016). Implementation of digital contents system for cleaning facility management based on bluetooth. *International Journal of Smart Home*, 10(7): 259–268. https://doi.org/10.14257/ijsh.2016.10.7.26

Ali, I., Aboelmaged, M.G., Govindan, K. and Malik, M. (2023). Understanding the key determinants of IoT implementation for the digital transformation of the food and beverage industry. *Industrial Management and Data Systems*, 123(7): 1887–1910. https://doi.org/10.1108/imds-02-2022-0082

Ali, O., Shrestha, A., Osmanaj, V. and Muhammed, S. (2020). Cloud computing technology implementation: An evaluation of key factors in local governments. *Information Technology and People*, 34(2): 666–703. https://doi.org/10.1108/itp-03-2019-0119

Alkhayatt, N.S. and Hagem, R.M. (2018). Smart home system based on Wi-Fi and IoT. *International Journal of Advances in Engineering and Technology*, 11(6): 155–161

Al-Obaidi, K.M., Hossain, M., Alduais, N.A.M., Al-Duais, H.S., Omrany, H. and Ghaffarianhoseini, A. (2022). A review of using IoT for energy efficient buildings and cities: A built environment perspective. *Energies*, 14(11): 3203. https://doi.org/10.3390/en15165991

Amini, M.H., Feizi-Derakhshi, M.R. and Fotuhi-Firuzabad, M. (2017). Electric energy management in residential areas through coordination of multiple smart homes. *Renewable and Sustainable Energy Reviews*, 72: 1–16. https://doi.org/10.1016/j.rser.2017.01.166

Anathan, J.D., Yusof, L.M. and Rahman, R.A. (2023). Internet of Things (IoT) impact on facility management of office Buildings: A qualitative study. *Journal of Engineering Project and Production Management*, 13(3): 20–31. http://doi.org/10.32738/JEPPM-2023-0020

Araszkiewicz, K. (2017). Digital technologies in facility management: The state of practice and research challenges. *Procedia Engineering*, 196: 1034–1042. https://doi:10.1016/j.proeng.2017.08.059

Atta, N. and Talamo, C. (2019). Digital transformation in facility management (FM): IoT and Big Data for service innovation. In B. Daniotti, M. Gianinetto and D. Torre (eds.), *Digital Transformation of the Design, Construction and Management Processes of the Built Environment*. Cham, Switzerland: Springer Open, 267–278. https://doi.org/10.1007/978-3-030-33570-0_24

Azizi, S., Nair, G., Rabiee, R. and Olofsson, T. (2020). Application of Internet of Things in academic buildings for space use efficiency using occupancy and booking data. *Building and Environment, 186*: 107355. https://doi.org/10.1016/j.buildenv.2020.107355

Baron, R.M. and Kenny, D.A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology*, 51(6): 1173–1182.

Bouabdallaoui, Y., Lafhaj, Z., Yim, P., Ducoulombier, L. and Bennadji, B. (2021). Predictive maintenance in building facilities: A machine learning-based approach. *Sensors*, 21(4): 1044. http://doi.org/10.3390/s21041044

Bousdekis, A., Apostolou, D. and Mentzas, G. (2020). Predictive maintenance in the 4th Industrial Revolution: Benefits, business opportunities and managerial implications. *IEEE Engineering Management Review*, 48(1): 57–62. https://doi.org/10.1109/emr.2019.2958037

Brad, B.S. and Murar, M.M. (2014). Smart buildings using IoT technologies. *Construction of Unique Buildings and Structures*, 5(20): 15–27. https://doi.org/10.18720/CUBS.20.2

Brous, P., Janssen, M. and Herder, P. (2018). Internet of Things implementation for reconfiguring decision-making processes in asset management. *Business Process Management Journal*, 24(3): 704–719. https://doi.org/10.1108/BPMJ-11-2017-0328

Chew, M.Y.L., Teo, E.A.L., Shah, K.W., Kumar, V. and Hussein, G.F. (2020). Evaluating the roadmap of 5G technology implementation for smart building and facilities management in Singapore. *Sustainability*, 12(23): 1–26. http://doi.org/10.3390/su122410259

Chung, S., Kwon, S., Moon, D. and Lee, S. (2018). Smart facility management systems utilizing open BIM and augmented/virtual reality. In J. Teizer, M. König and T. Hartmann (eds.), *Proceedings of the 35th International Symposium on Automation and Robotics in Construction (ISARC 2018)*. Berlin: ISARC, 1–9. https://doi.org/10.22260/ISARC2018/0118

Codinhoto, R., Fabricio, M. and Fialho, B. (2020). Trends in BIM and IoT for reactive maintenance. Paper presented at the CIB W78 Conference 2020: Innovation in Information and Communication Technology in the Built Environment. São Paulo, Brazil, 11–13 November.

Collotta, M. and Pau, G. (2015). Bluetooth for Internet of Things: A fuzzy approach to improve power management in smart homes. *Computers and Electrical Engineering*, 44: 137–152. http://doi.org/10.1016/j.compeleceng.2015.01.005

Dang, K. and Trotskii, I. (2019). Architecture for automation system metrics collection, visualization and data engineering: HAMK sheet metal center building automation case study. *Open Engineering*, 9: 561–570. https://doi.org/10.1515/eng-2019-0065

Dawod, A., Georgakopoulos, D., Jayaraman, P.P., Nirmalathas, A. and Parampalli, U. (2022). IoT device integration and payment via an autonomic blockchain-based service for IoT device sharing. *Sensors*, 22(4): 1344. https://doi.org/10.3390/s22041344

Dlesk, A., Strogonov, V., Vach, K. and Pollert, J. (2023). Integration of spatially oriented data from IoT to facility management and BIM. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLVIII-5/W2: 31–36. https://doi.org/10.5194/isprs-archives-xlviii-5-w2-2023-31-2023

Dosumu, O. and Uwayo, S.M. (2023). Modelling the implementation of Internet of things (IoT) for sustainable construction in a developing economy. *Built Environment Project and Asset Management*, 13(3): 394–411. https://doi.org/10.1108/bepam-08-2022-0123

Ford, R., Pritoni, M., Sanguinetti, A. and Karlin, B. (2017). Categories and functionality of smart home technology for energy management. *Building and Environment*, 123: 543–554. http://doi.org/10.1016/j.buildenv.2017.07.020

Fossati, C., Stoppani, C., Menon, A., Pierannunzii, L., Compagnoni, R. and Randelli, P. (2021). Arthroscopic rotator cuff repair in patients over 70 years of age: A systematic review. *Journal of Orthopaedics and Traumatology*, 22(1). https://doi.org/10.1186/s10195-021-00565-z

Fung, C., Besser, M. and Poon, K.K.E. (2021). Systematic literature review of flipped classroom in mathematics. *Eurasia Journal of Mathematics, Science and Technology Education*, 17(6): em1974. https://doi.org/10.29333/ejmste/10900

Gbadamosi, S.A., Hancke, G.P. and Abu-Mahfouz, A.M. (2020). Building upon NB-IoT networks: A roadmap towards 5G new radio networks. *IEEE Access*, 8: 188641–188672. https://doi.org/10.1109/access.2020.3030653

Haddaway, N.R., Page, M.J., Pritchard, C.C. and McGuinness, L.A. (2022). PRISMA2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis. *Campbell Systematic Reviews*, 18(2). https://doi.org/10.1002/cl2.1230

Kabra, G. (2023). Determinants of blockchain implementation and organizational performance in the healthcare sector in India. *American Journal of Business*, 38(3): 152–171. http://doi.org/10.1108/AJB-12-2022-0206

Kanna, K., Lachguer, K.A. and Yaagoubi, R. (2022). An integration of BIM-IoT-machine learning for optimizing indoor thermal comfort based on user experience. *Energy and Buildings*, 277: 112547. http://doi.org/10.1016/j.enbuild.2022.112547

Konanahalli, A., Marinelli, M. and Oyedele, L. (2020). Drivers and challenges associated with the implementation of big data within U.K. facilities management sector: An exploratory factor analysis approach. *IEEE Transactions on Engineering Management*, 69(4): 916–929. https://doi.org/10.1109/tem.2019.2959914

Lee, J.Y., Irisboev, I.O. and Ryu, Y.-S. (2021). Literature review on digitalization in facilities management and facilities management performance measurement: Contribution of Industry 4.0 in the global era. *Sustainability*, 13(23): 13432. https://doi.org/10.3390/su132313432

Li, S., Xu, L.D. and Zhao, S. (2014). The Internet of Things: A survey. *Information Systems Frontiers*, 17(2): 243–259. http://doi.org/10.3390/smartcities4030051

Lockwood, C., Munn, Z. and Porritt, K. (2015). Qualitative research synthesis: Methodological guidance for systematic reviewers utilizing meta-aggregation. *International Journal of Evidence-Based Healthcare*, 13(3): 179–187. https://doi.org/10.1097/xeb.0000000000000062

Maskuriy, R., Selamat, A., Ali, K.N., Marešová, P. and Krejcar, O. (2019). Industry 4.0 for the construction industry: How ready is the industry? *Applied Sciences*, 9(14): 2819. https://doi.org/10.3390/app9142819

Munn, Z., Peters, M.D.J., Stern, C., Tufanaru, C., McArthur, A. and Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology*, 18(1): 1–7. https://doi.org/10.1186/s12874-018-0611-x

Nikolić, V., Stević, Z., Janićijević, S., Kreculj, D. and Comtrade, B. (2020). Possibilities of IIoT application platforms in the electrical power systems. Paper presented at the 8th International Conference on Renewable Electrical Power Sources. Trebinje, Bosnia and Herzegovina, 1–2 June.

Opoku, A. and Lee, J.Y. (2022). The future of facilities management: Managing facilities for sustainable development. *Sustainability*, 14(3): 1705. http://doi.org/10.3390/su14031705

Pasek, J. and Sojkova, V. (2018). Facility management of smart buildings. *International Review of Applied Sciences and Engineering*, 9(2): 181–187. http://doi.org/10.1556/1848.2018.9.2.15

Pellegrini, L., Seghezzi, E., Tagliabue, L.C., Di Giuda, G.M., Schievano, M. and Tucci, A. (2022). Decision Support system for occupancy-oriented facility management: Methodology and first results. In *Proceedings of the 2022 European Conference on Computing in Construction*. Rhodes: European Council on Computing in Construction, 1–8. http://doi.org/10.35490/EC3.2022.204

Piantanida, P., Siccardi, S., Aliev, K. and Villa, V. (2023). Lighting maintenance management through IoT-Based automated fault diagnostics. *Proceedings of International Structural Engineering and Construction*, 10(1): FAM-03. http://doi.org/10.14455/ISEC.2023.10(1).FAM-03

Pimsakul, S., Samaranayake, P. and Laosirihongthong, T. (2021). Prioritizing enabling factors of IoT implementation for sustainability in supply chain management. *Sustainability*, 13(22): 12890. https://doi.org/10.3390/su132212890

Raendran, V., Ramasamy, R.K., Rosdi, I.S. and Razak, R.A. (2020). IoT technology for facilities management: Understanding end user perception of the smart toilet. *International Journal of Advanced Computer Science and Applications*, 11(5). http://doi.org/10.14569/IJACSA.2020.0110547

Rafsanjani, H.N. and Ghahramani, A. (2020). Towards utilizing Internet of Things (IoT) devices for understanding individual occupants' energy usage of personal and shared appliances in office buildings. *Journal of Building Engineering*, 27:100948. https://doi.org/10.1016/j.jobe.2019.100948

Rafsanjani, H.N., Ghahramani, A. and Nabizadeh, A.H. (2020). iSEA: IoT-based smartphone energy assistant for prompting energy-aware behaviors in commercial buildings. *Applied Energy*, 266: 114892. https://doi.org/10.1016/j.apenergy.2020.114892

Sanzana, M.R., Maul, T., Wong, J.Y., Abdulrazic, M.O.M. and Yip, C.-C. (2022). Application of deep learning in facility management and maintenance for heating, ventilation and air conditioning. *Automation in Construction*, 141: 104445. https://doi.org/10.1016/j.autcon.2022.104445

Sarkar, A. (2021). Importance of IoT in facility management. *International Journal of Recent Scientific Research*, 12(6). http://doi.org/10.24327/ijrsr.2021.1206.xx

Schröeder, A., Naik, P., Bigdeli, A. Z. and Baines, T. (2020). Digitally enabled advanced services: a socio-technical perspective on the role of the Internet of Things (IoT). *International Journal of Operations and Production Management*, 40(7/8): 1243–1268.

Sidek, N., Ali, N. and Alkawsi, G. (2022). An integrated success model of Internet of Things (IoT)-Based services in facilities management for public sector. *Sensors*, 22(9): 3207. http://doi.org/10.3390/s22093207

Solomon, D. (2013). Types of open access publishers in Scopus. *Publications*, 1(1): 16–26. https://doi.org/10.3390/publications1010016

Stern, C., Jordan, Z. and McArthur, A. (2014). Developing review questions and inclusion criteria. In *The Joanna Briggs Institute Reviewer's Manual*. Adelaide: The Joanna Briggs Institute.

Talamo, C., Pinto, M.R., Viola, S. and Atta, N. (2019). Smart cities and enabling technologies: influences on urban Facility Management services. *IOP Conference Series: Earth and Environmental Science*, 296: 012047. https://doi.org/10.1088/1755-1315/296/1/01204

Tornatzky, L.G. and Fleischer, M. (1990). *The Processes of Technological Innovation*. Lexington, MA: Lexington Books.

Valinejadshoubi, M., Moselhi, O., Bagchi, A. and Salem, A. (2021). Development of an IoT and BIM-based automated alert system for thermal comfort monitoring in buildings. *Sustainable Cities and Society*, 66: 102602. http://doi.org/10.1016/j.scs.2020.102602

Wang, D., Jing, K.T., Kan, Z. and Li, Y. (2020). Exploring the application of digital data management approach for facility management in Shanghai's high-rise buildings. *Progress in Energy and Environment*, 13: 1–15.