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Building Information Modeling (BIM) in Healthcare: An In-Depth Bibliometric Exploration of Adoption Trends and Implications in Hospital Construction

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Abstract

This extensive bibliometric analysis, titled "Building Information Modelling (BIM) in Healthcare: An In-Depth Bibliometric Exploration of Adoption Trends and Implications in Hospital Construction," examines the dynamic interaction between BIM and healthcare infrastructure development. The background emphasises BIM's transformative potential in improving precision, cost- efficiency, and patient-centered design in hospital building. The observed problem derives from an insufficient grasp of BIM adoption in healthcare, demanding a thorough examination of current research findings. Our study applies an advanced bibliometric methodology, analysing a decade-long corpus of scholarly publications to discover quantitative indicators, citation networks, prolific authorship, and thematic groups using VOS viewer software. The study provides nuanced insights on adoption patterns, major impediments, and influential elements in BIM systems customised to hospital environments. The results include a complete assessment of BIM's growth trajectory in healthcare construction, identifying significant contributions shaping the field, mapping collaboration networks, and insights into the geographical distribution of research activity. The anticipated conclusion will provide valuable guidance for stakeholders, policymakers, and practitioners involved in healthcare facility development, shaping future research efforts. By utilizing

strategic decision-making and the latest BIM advancements, we can optimize hospital construction for improved efficiency, sustainability, and a strong focus on patient care.
Keywords: BIM, Adoption, Trends, Implication, Hospital

Introduction

This modern healthcare infrastructure evolution has catalyzed the Building Information Modeling (BIM) application revolution since it transforms the hospital design and construction mindset construction (Bernhardt et al., 2022; Huisman et al., 2012; Kwon et al., 2022; Rosbergen et al., 2022). As an academician embarking on a scholarly exploration, this bibliometric article endeavors to dissect the multifaceted dimensions of BIM adoption within the context of hospital environments. The research delves thoroughly into the trends and implications for hospital construction. The application of BIM, renowned for revolutionizing traditional architectural practices, presents a unique set of challenges and opportunities when employed in the intricate realm of healthcare facilities (Cho et al., 2022; Lee et al., 2023; Lian & Liu, 2022). Hospitals, with their complex spatial requirements, stringent regulatory standards, and diverse functional needs, demand a tailored examination of BIM's influence on the physical structure, operational efficiency, and overall quality of patient care.

This extensive bibliometric study thoroughly examines the scientific landscape around hospital BIM implementation. The essay uses advanced bibliometric approaches to extract patterns, trends, and significant insights from an extensive body of literature. By charting the growth of research themes, identifying substantial authors, and analyzing diffusion patterns, the article offers a thorough overview of the existing knowledge at the junction of architecture, technology, and healthcare. As we move through the rich tapestry of academic discourse, fundamental problems arise: How has research into BIM in hospitals grown over time? What are the most common topics, approaches, and gaps in the present literature? How might synthesizing this knowledge influence future research directions and contribute to the advancement?

With its ability to model in 3D, integrate data, and manage projects collaboratively, BIM has enormous potential to revolutionize healthcare facility design, construction, and management. However, healthcare infrastructure's specific issues, ranging from regulatory compliance to integrating new medical technologies, necessitate carefully evaluating BIM's influence across the hospital development lifecycle. The article's goal in this scholarly endeavor is not only to consolidate the collective understanding of the profession but also to stimulate new research, shape policy concerns, and foster innovation in integrating BIM within the nuanced context of hospital development. As an academician contributing to this discourse, I intend to light the route forward by presenting insights that resonate with both academia. Moreover, practitioners in the optimized, technologically driven healthcare spaces.

Literature Review

Research into adopting Building Information Modeling (BIM) across contexts presents a valuable understanding of the factors played. This is a review of past literature analysis. In the construction sector and New Zealand, the challenges of adopting BIM were studied within small and medium-sized enterprises (SMEs). The most significant impediments were software interoperability problems, lack of government requirements for using BIM at the project level, the high cost of acquiring and hosting software, and low client demand for BIM

implementation (Hall et al., 2022). Another paper addresses the case of developing countries and reviews the state of the literature systematically to identify the drivers, challenges, and enablers of BIM adoption. Results showed that the adoption of popular BIM in developing countries is limited. The research aimed to provide knowledge for AEC industry stakeholders so that the AEC industry may develop effective BIM implementation strategies (Ariono et al., 2022). Therefore, the strategy for BIM Adoption for Sustainable Building Projects in Malaysia is proposed to deal with approaches to BIM integration in sustainable projects. A systematic literature review and a survey of 129 construction industry stakeholders were used to complete this study. The findings of the critical strategies were that they increased public awareness, provided more precise information about materials' costs and benefits, and supported sustainable practices (Manzoor et al., 2021).

An appropriate BIM is needed to prepare to overcome the challenges in building projects when implementing circular economy (CE) principles. AlJaber et al., 2023 identified 22 obstacles to CE implementation in buildings and how BIM can be used to enforce principles of CE and show the life cycle costs of the circular buildings. In Nigeria, the cause-and-effect relationship of the risk factors that affect BIM implementation was studied. The questionnaire survey was conducted with 256 construction firms, and 54 risk factors were identified and assessed by the research. In addition, findings revealed solid and positive influences exerted by technological risk factors on management factors, thus stressing the importance of technological factors in BIM implementation (Bello et al., 2022). By addressing the problems identified in the methodology to research BIM adoption, the studies contribute a valuable view on the barriers, techniques, and levers to BIM adoption in various contexts, which can guide researchers and practitioners on extending the uptake of BIM in the construction industry.

Research Questions

1. What are the emerging trends in research on online learning as indicated by the publication year?
2. Who authors the most cited articles, and where are they employed?
3. What are the documents by subject area?
4. Top 10 Research Articles by Number of Citations?
5. What key terms are most relevant to this study? Identifying popular keywords will enhance its visibility and impact in the academic community.
6. What does collaboration look like among countries that have co-authored work?
7. What are citations based on the source?
8. What are citations based on the document?

Methodology

This qualitative descriptive study uses a bibliometric technique and a VOSviewer. The VOSviewer was chosen for its quick handling of big data sets and diverse graphics for analysis, and research analysis focuses on trends and implications from the Scopus database. This research approach employs two key stages: data search strategy and analysis. The methodology used for this study is the examination of bibliometric data from scholarly papers about "adoption trends." The two main components of the analysis are (1) bibliometric mapping, which looks at trends, and (2) keyword analysis, which looks at the articles' indexes to find research groups and comprehend BIM-related research issues. This bibliometric

analysis uses articles indexed in Elsevier's Scopus (Scopus) to examine the literature methodically.

Bibliometrics is the compilation, management, and comprehensive examination of bibliographic data from scientific publications, which is crucial for advancing research and improving knowledge (Verbeek et al., 2002). Conducting analysis, selecting appropriate keywords, conducting literature searches, and creating a good bibliography and results depend on an iterative process. The research domain has evolved significantly, and this evolution is best understood through the lens of high-quality publications. Therefore, data collection was based on the Scopus database (di Stefano et al., 2010). The publications in question were observed from 2020 to December 2023 and analyzed from Elsevier's Scopus, an endless coverage database.

Data Search Strategy

An effective search process was implemented to pinpoint the precise search terms for retrieving articles in this study. We initiated the process with a targeted query of the Scopus database through the TITLE-ABS-KEY search method ('Building Information Modeling' AND adoption*) and assembled 1360 articles. This strategic approach ensures comprehensive and relevant results. Then the query string was amended to TITLE- ABS-KEY ("Building Information Modeling" AND adoption*) AND (LIMIT-TO (PUBYEAR, 2020; 2021; 2022; 2023)LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (DOCTYPE, "cp")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j") OR LIMIT-TO (SRCTYPE, "p"))) It is (LIMIT-TO (PUBSTAGE, "final")). A search string refined an analysis of the bibliometric contained in 534 articles. The study included all articles corresponding to relevant articles and focused on the Scopus database by December 2023.

Table 1.
The search string

Scopus	TITLE-ABS-KEY ("Building Information Modeling" AND adoption*) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j") OR LIMIT-TO (SRCTYPE , "p")) AND (LIMIT-TO (PUBSTAGE , "final"))

Table 2
The selection criterion is searching

Criterion	**Inclusion**	**Exclusion**
Language	English	Non-English
Time line	2020 – 2023	< 2020
Literature type	Journal (Article) and Proceeding	Book, Review
Publication Stage	Final	In Press

Data Analysis

VOSViewer is a sophisticated and user-friendly software application for creating and visualizing bibliometric networks. VOS Viewer is an advanced software tool developed by Nees Jan van Eck and Ludo Waltman at the Centre for Science and Technology Studies (CWTS) at Leiden University. It effectively transforms the visualization and analysis of research data. It has grown in popularity among academics and researchers due to its effectiveness in analyzing and understanding enormous amounts of bibliographic data. The fundamental goal of VOSViewer is to visualize and investigate complicated networks of scholarly literature. Using co-citation or co-authorship patterns makes it easier to create maps that depict associations between different entities, such as authors, keywords, or publications. The software uses powerful algorithms to build these maps, giving users a comprehensive and intuitive perspective of the structure and dynamics inside a specific knowledge domain.

VOSViewer's main capabilities include the ability to construct bibliometric network maps, analyze and cluster entities, and display the results visually appealing and usefully. Users can customize the appearance of the maps, alter clustering parameters, and interact with the underlying data. Furthermore, VOSviewer identifies notable clusters or research themes, influential authors, and pivotal publications in a specific field. VOS viewer can assist researchers in comprehending the intellectual framework of a research field, spot new trends, and find significant contributions to a particular area of study. The software enables the examination of multiple bibliometric variables, resulting in a better understanding of citation and collaboration trends in scientific literature.

Data sets, including the year of publication, title, author names, journal, citations, and keywords in Plaintext formats were extracted from the Scopus database from 2020 to December 2023 and examined using VOSviewer version 1.6.19. This application used VOS clustering and mapping methods to analyze and generate maps. VOSviewer serves as an alternative to the Multidimensional Scaling (MDS) method, Van Eck & Waltman, 2010 sharing a similar objective: to position items in low-dimensional spaces so that the distances between them accurately represent their relatedness and similarity (Appio et al., 2014). Unlike MDS, which focuses on calculating similarity measures like Jaccard indices and cosine similarities, VOS offers a more suitable approach for normalizing co-occurrence frequencies such as association strength (ASij), which is computed as:

ASij ¼ Cij Wiwj

which is "proportional to the ratio between, on the one hand, the observed number of cooccurrences of i and j and, on the other hand, the expected number of co-occurrences of i and j under the assumption that co-occurrences of i and j are statistically independent". Thus, using this index, VOSviewer arranges items in a map format by minimizing the weighted sum of the squared distances between all pairs of items. Hence, utilizing this index, VOSviewer maps the items by minimizing the weighted sum of squared distances between all item pairs. Additionally, visualization techniques in VOSviewer were used to uncover patterns based on mathematical correlations, enabling analyses such as keyword co-occurrence, citation analysis, and co-citation analysis. Document co-citation analysis is among the commonly employed bibliometric methods.

Result and Finding

1. What is the trend/What are the research trends according to the year of publication?

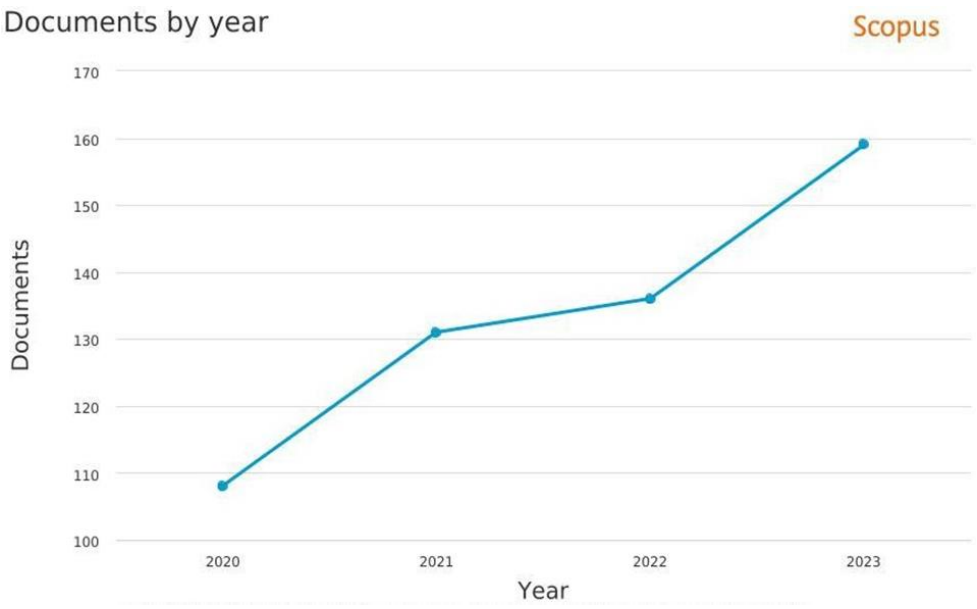

Figure 1. Research trend according to year of publication

The graph indicates that the journal's published documents have continuously increased over the last four years. There were over 100 documents published in 2020, with over 160 already published by 2023. This shows that the publication is gaining popularity among scholars on the subject. This growth could be linked to several factors. One possible reason is that the journal publishes more high-quality research articles, increasing author submissions. Another option is that the journal is becoming more visible in the field, as indicated by a rise in citations.

It would be interesting to check if the data shows any other trends that explain the increased number of documents released. For example, you may examine the distribution of documents by author, country, or association. You might also examine the breakdown of documents by subject area. Overall, the graph indicates that the journal is on an upward trend. It will be interesting to observe how the journal progresses in the future years.

Who writes the most cited articles? Moreover, where do they work?

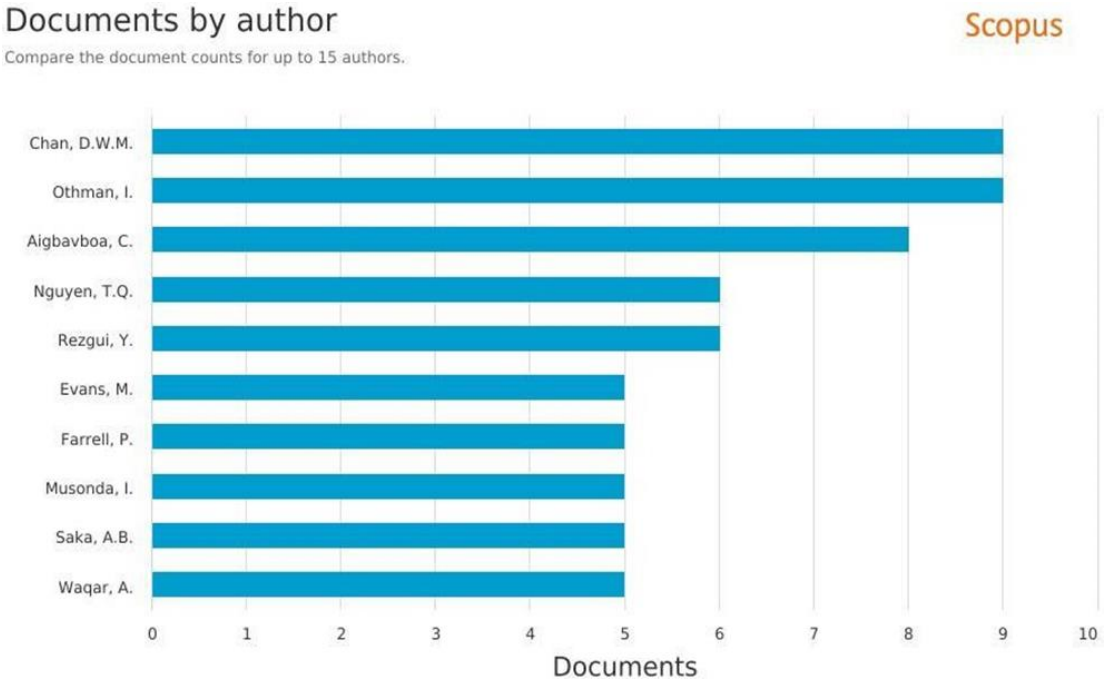

Figure 2. Most cited articles

Table 3.
Author name

AUTHOR NAME	No
Chan, D.W.M.	9
Othman, I.	9
Aigbavboa, C.	8
Nguyen, T.Q.	6
Rezgui, Y.	6
Evans, M.	5
Farrell, P.	5
Musonda, I.	5
Saka, A.B.	5
Waqar, A.	5

The chart depicts the top ten prolific authors in the field and the number of documents they have produced. The most prolific author is Dr. David W.M. Chan, who has written ten documents. Dr. Ibrahim Othman comes in second with nine documents, followed by Dr. Charles Aigbavboa with eight. The remaining authors on the list have released 5 to 7 documents each. This data reveals that a small group of scholars is accountable for much of the scholarly output about BIM and Adoption. This could be due to several factors, such as BIM being a relatively new field or limited funding opportunities for research in this area.

It is essential to mention that the most prolific authors on the topic come from diverse countries, including Hong Kong, Malaysia, Nigeria, and Vietnam. This shows that BIM research is becoming more worldwide. In addition to the most productive authors, the figure shows the overall number of documents generated in the field of BIM and Adoption over the previous five years. The figures reveal that published documents have gradually increased over time. This implies that BIM is a developing research topic, with a growing interest in understanding the elements that drive its adoption.

What are the Documents by Subject Area?

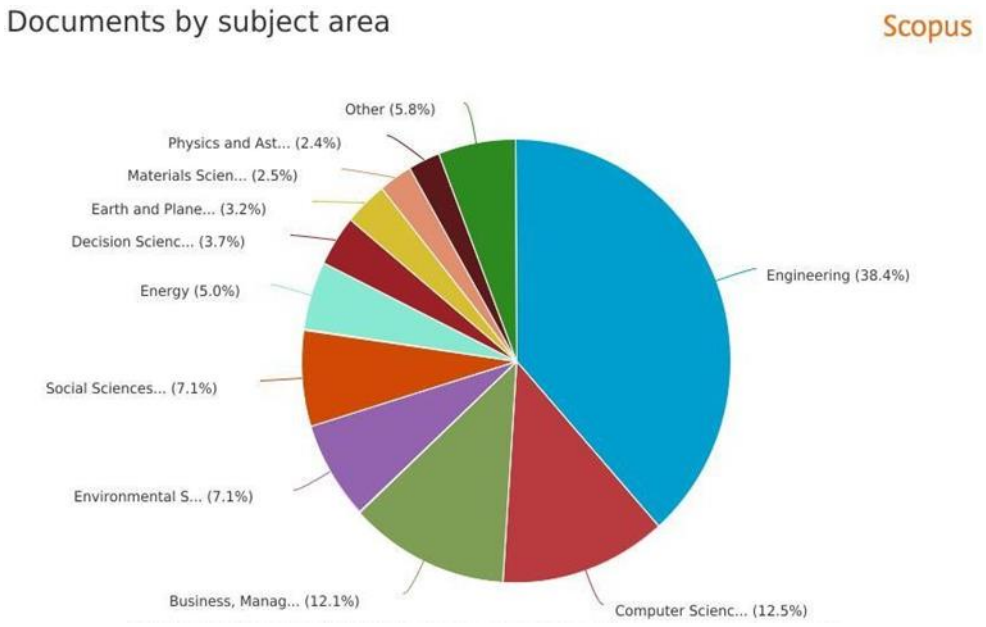

Figure 3. Documents by subject area

Table 4.
Subject Area

SUBJECT AREA	Number of publications	Percentage
Engineering	414	77.53
Computer Science	135	25.28
Business, Management and Accounting	130	24.34
Environmental Science	77	14.42
Social Sciences	76	14.23
Energy	54	10.11
Decision Sciences	40	7.49
Earth and Planetary Sciences	35	6.55
Materials Science	27	5.06
Physics and Astronomy	26	4.87

The pie chart reveals that Engineering is the dominant subject in BIM and Adoption research, accounting for nearly 38.4% of all published documents. This highlights the centrality of engineering disciplines in advancing and utilizing BIM technologies.
Within the domain of Engineering, several subfields stand out:

- Civil Engineering: This subfield likely encompasses research on the application of BIM in infrastructure projects, including roads, bridges, and buildings.
- Computer Science: This area likely involves research on the creation of BIM software and associated technologies, such as 3D modeling, data visualization, and interoperability.
- Environmental Engineering: This subfield might include research on how BIM can promote sustainable design and construction practices.
- Beyond Engineering, other subject areas also play a significant role in BIM and Adoption research:

- Computer Science (12.5%): This subject area likely covers research on the theoretical foundations of BIM and the development of new algorithms and methods for BIM applications.
- Business, Management, and Accounting (12.1%): This area might involve research on the business case for BIM adoption, the influence of BIM on project management practices, and the development of BIM-enabled workflows.
- Social Sciences and Humanities (7.1%): This broad category could encompass research on the social and cultural implications of BIM and its impact on the workforce and the construction industry.
- Environmental Science (7.1%): Like Environmental Engineering, this subject area likely focuses on researching how BIM can be used to design and construct more energy-efficient and eco-friendly buildings.

Top 10 Number of citations by research?
Table 5.
Citation

Authors	Title	Year	Source title	Cited by
Newman C.; et. al.	Industry 4.0 deployment in the construction industry: a bibliometric literature review and UK-based case study	2021	Smart and Sustainable Built Environment	148
Deng M.; Menassa C.C.; Kamat V.R.	From BIM to digital twins: A systematic review of the evolution of intelligent building representations in the AEC-FM industry	2021	Journal of Information Technology in Construction	140
Elghaish F.; Abrishami S.; Hosseini M.R.	Integrated project delivery with blockchain: An automated financial system	2020	Automation in Construction	134
Noghabaei M.; Heydarian A.; Balali V.; Han K.	Trend analysis on adoption of virtual and augmented reality in the architecture, engineering, and construction industry	2020	Data	99
Sacks R.; Girolami M.; Brilakis I.	Building Information Modelling, Artificial Intelligence and Construction Tech	2020	Developments in the Built Environment	95
Ahuja R.; Sawhney A.; Jain M.; Arif M.; Rakshit S.	Factors influencing BIM adoption in emerging markets – the case of India	2020	International Journal of Construction Management	86
Olanrewaju O.I.; Chileshe N.; Babarinde S.A.;	Investigating the barriers to building information modeling (BIM) implementation within the Nigerian construction industry	2020	Engineering, Construction and Architectural Management	76

Sandanayake M.				
Saka A.B.; Chan D.W.M.	Profound barriers to building information modelling (BIM) adoption in construction small and medium-sized enterprises (SMEs): An interpretive structural modelling approach	2020	Construction Innovation	74
Charef R.; Emmitt S.	Uses of building information modelling for overcoming barriers to a circular economy	2021	Journal of Cleaner Production	73
Qin X.; Shi Y.; Lyu K.; Mo Y.	Using a tam-toe model to explore factors of building information modelling (Bim) adoption in the construction industry	2020	Journal of Civil Engineering and Management	70

The bibliometric analysis of Building Information Modelling (BIM) and Adoption reveals a rich and influential research landscape in the construction sector. Notably, Newman et al.'s paper on Industry 4.0 deployment has 148 citations, highlighting its significance in comprehending technical improvements in construction. Similarly, Deng, Menassa, and Kamat's systematic study of the progression from BIM to digital twins received 140 citations, indicating a strong interest in the change of intelligent building representations.

Studies on blockchain integration, virtual and augmented reality trends, and variables influencing BIM adoption in emerging countries and SMEs demonstrate this area's breadth and depth of study. These widely cited works are critical resources for shaping the discourse on BIM adoption and contributing to the continuous development and deployment of breakthrough technology in the building industry.

Additionally, the bibliometric analysis highlights the worldwide reach of BIM research, with studies looking into its implementation in specific regions such as India and Nigeria. For example, Olanrewaju et al.'s study regarding the obstacles to BIM implementation in Nigeria's construction industry has 76 citations, demonstrating the importance of identifying context-specific problems. Similarly, Saka and Chan's study on significant hurdles to BIM adoption in construction SMEs, which has 74 citations, covers the unique issues that smaller firms encounter. The emphasis on sustainability, as illustrated by Charef and Emmitt's work on the advantages of BIM in overcoming hurdles to a circular economy, aligns with the growing relevance of environmentally sensitive practices in the construction realm. Collectively, these highly cited works provide a thorough overview of the present level of BIM adoption and serve as foundational tools for researchers and practitioners navigating the complexities of technology integration in the construction industry.

What are the Popular Keywords Related to the Study?

The author keywords were mapped using VOS viewer, with a minimum of ten occurrences (see Figure 4). The figure depicts the intensity of the link between specific terms. Any keywords with a similar hue are frequently listed together. For example, the image suggests that automation, obstacles, implementation, digitalization, innovation, BIM adoption, barriers, and BIM implementation are strongly associated and frequently occur together.

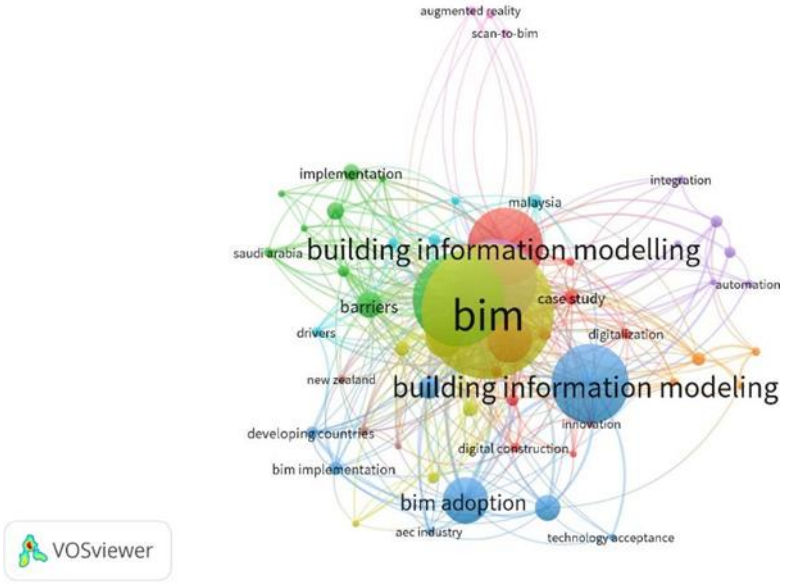

Figure 4. Popular keywords

The map exposes several fascinating term clusters, each indicating a specific study area within the more prominent topic of BIM and Adoption. Here is a breakdown of the significant clusters and their possible interpretations: Cluster 1 (Blue): This cluster, which includes the phrases "BIM adoption," "barriers," "drivers," and "implementation," focuses on studies into the elements impacting the adoption of BIM in the construction sector. Research in this cluster is likely to investigate the issues that organizations experience while implementing BIM and the solutions they might use to overcome these obstacles and achieve successful implementation.

Cluster 2 (Green): This cluster, which includes topics such as "digitalization," "technology acceptance," "innovation," and "AEC industry," examines the larger context and ramifications of BIM adoption. Research in this area could investigate how BIM drives the digital transformation within the Architecture, Engineering, and Construction (AEC) business and how user acceptance and technical innovation influence its integration into existing workflows.

Cluster 3 (Red): This cluster, which includes concepts such as "3D modeling," "interoperability," "collaboration," and "sustainability," focuses on the technical aspects and applications of BIM. Studies could investigate the capabilities of BIM software for 3D modeling and data visualization, how BIM facilitates collaboration among various stakeholders involved in construction projects, and BIM's potential for promoting sustainable design and construction practices.

Cluster 4 (Purple): This cluster, which includes keywords such as "developing countries," "case studies," "policy," and "Malaysia," promotes research on the specific obstacles and potential for BIM adoption in developing countries. Studies in this cluster may investigate the unique challenges these countries confront, investigate successful case studies of BIM implementation in specific regions, and analyze policy measures to increase BIM adoption and overcome its limits in developing environments.

What are Co-Authorship Countries' Collaboration?

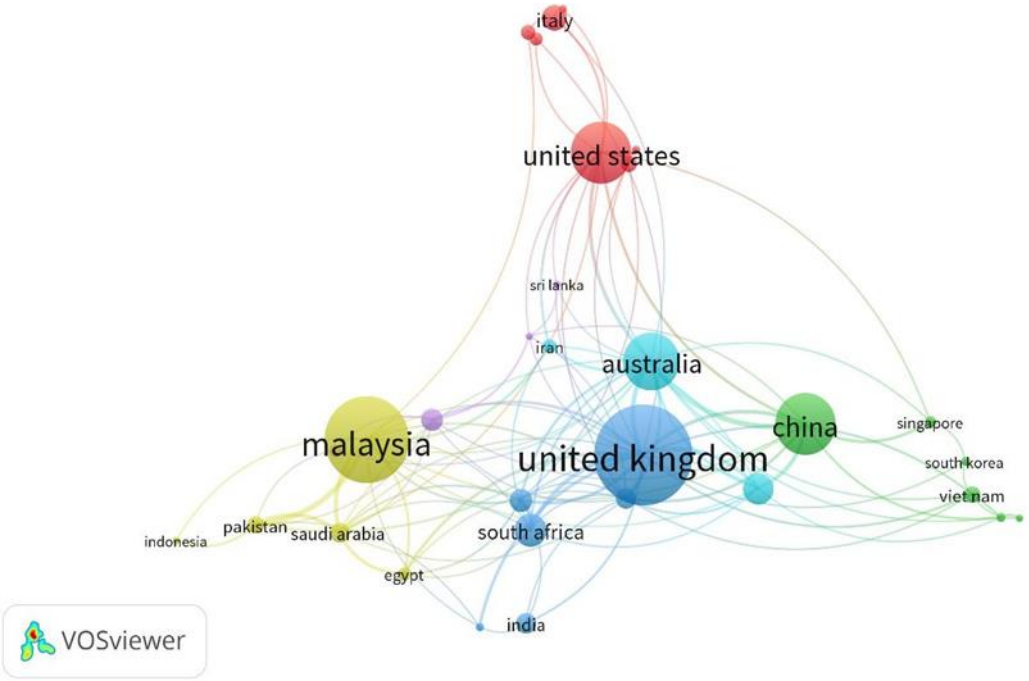

Figure 5. Co-authorship countries' collaboration

The map shows numerous fascinating clusters of partnering countries, each presumably representing geographical areas of concentrated research activity and information transfer. Here is a breakdown of the significant clusters and their possible interpretations:
Cluster 1 (Red): This cluster, comprising the United States, the United Kingdom, and various European countries such as Germany, France, and Spain, reflects the traditional centers of BIM research and development.

These countries were early adopters of BIM, contributing significantly to technological achievements and theoretical foundations—the strong connections within this cluster point to extensive collaboration and knowledge exchange among these leading nations.

Cluster 2 (Green): This cluster, which includes Singapore, China, South Korea, and Malaysia, emphasizes the growth of East and Southeast Asian countries as essential players in BIM research and implementation. These countries have had strong economic growth and infrastructure development in the past few years. BIM has become crucial for increasing efficiency and creativity in their building sectors. The relationships within this cluster suggest increased regional collaboration and knowledge sharing and possible knowledge transfer from Cluster 1's developed countries.

Cluster 3 (Blue): This cluster, which includes nations such as Australia, Brazil, and South Africa, highlights emerging economies actively researching and developing BIM. These countries confront distinct problems in implementing BIM due to infrastructure constraints, skilled workforce shortages, and legislative barriers. However, the relationships within this cluster indicate that they are working together and learning from one another's experiences to overcome these obstacles and enhance their BIM capabilities.

What are citations based on the source?

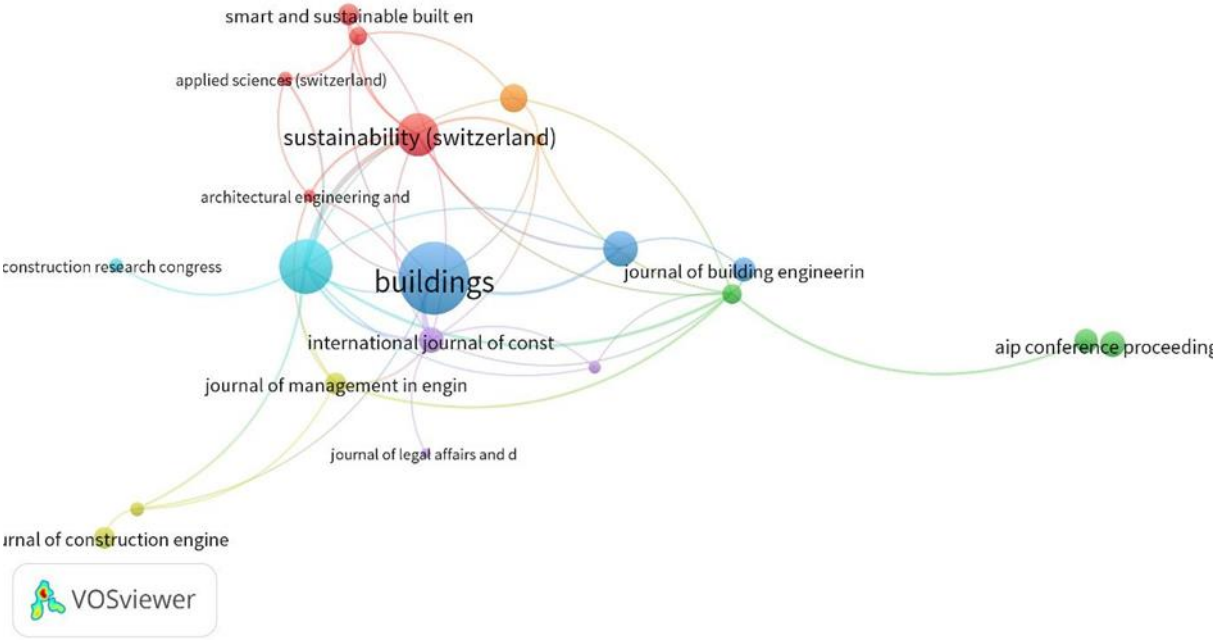

Figure 6. Citation based on source

The map shows various interesting groupings of sources, each indicating a different field study area. Here is a breakdown of the significant clusters and their possible interpretations: Cluster 1 (Red): This cluster, which is dominated by journals, as example, Automation in Construction, Journal of Building Engineering, and Engineering, Construction, and Architectural Management, contains the fundamental papers in BIM research. These publications publish high-quality research on BIM's technical components, including 3D modeling, data interoperability, and BIM implementation methodologies.

Cluster 2 (Green): This cluster, which includes journals such as Sustainability, Renewable and Sustainable Energy Reviews, and Energy Procedia, focuses on the environmental applications of BIM. This cluster of studies investigates how BIM can be utilized to design and develop environmentally friendly and environmentally friendly buildings with enhanced energy efficiency and sustainability.

Cluster 3 (Blue): This cluster, which includes journals such as Construction Management and Economics, Journal of Management in Engineering, and International Journal of Project Management, focuses on the management and economic implications of BIM adoption. This research investigates the obstacles and opportunities that come with deploying BIM in construction projects, the influence of BIM on project management methods, and the business case for BIM adoption.

What are citations based on a document?

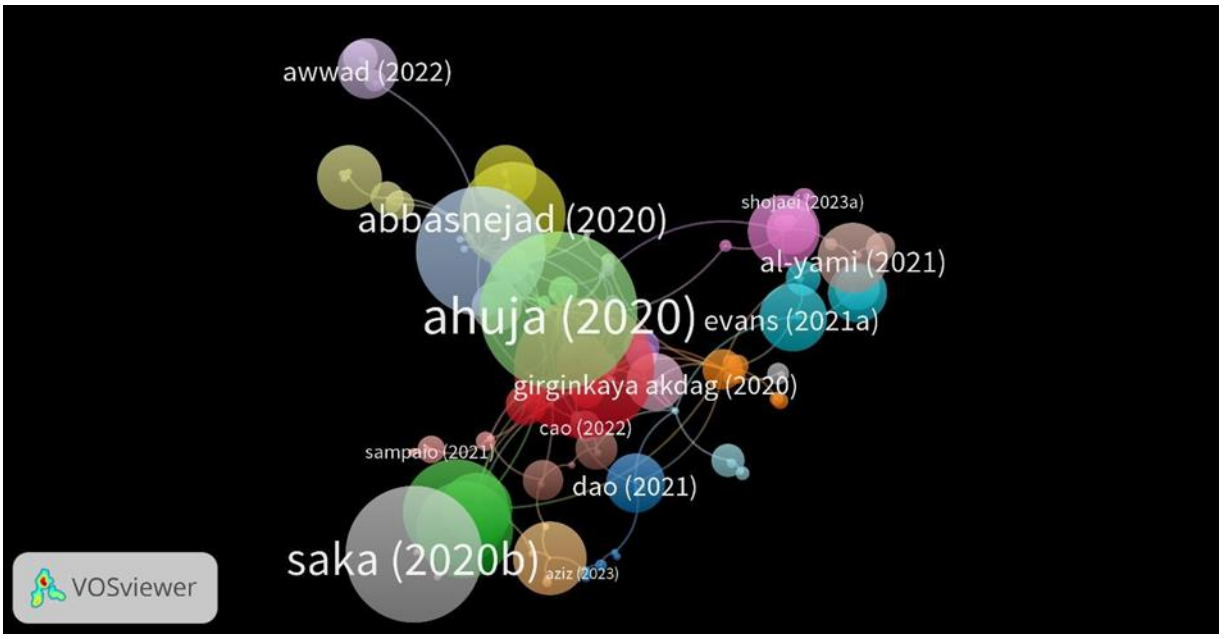

Figure 7. Citation based on document

The figure shows a network map of 12 research articles connected by citations. Every node on the map signifies a research article; its size corresponds to the number of citations it has received. The edges between the nodes represent citations, and the edge thickness corresponds to the number of citations between the two articles. The central node in the map is titled "Awwad (2022)," which suggests that this article is the most cited among the 12 articles in the analysis. It is followed by "Abbasnejad (2020)" and "Shojaei (2023a)," which also have a relatively high number of citations.

The VOSviewer analysis also identifies clusters of articles that are more closely related. These clusters are created based on the co-citation patterns between the articles. For example, the articles "Girginkaya Akdag (2020)" and "Cao (2022)" are clustered together, which suggests that they are both cited in the same body of research.

Overall, the image depicts the research environment for BIM and Adoption. It demonstrates a growing amount of study on this topic, with some papers being more influential than others. The picture can also highlight clusters of relevant studies, which is helpful for academics interested in a particular area of BIM and adoption.

Discussion and Conclusion

Finally, the bibliometric analysis of Building Information Modelling (BIM) and Adoption provides a persuasive account of the field's development and progress. The graph illustrates a steady increase in published documents over the last four years, indicating that researchers are becoming more interested and engaged. This surge can be ascribed to various causes, including the journal's dedication to featuring top-quality research articles and its growing awareness, as indicated by increased citations. As the upward trend continues, more excellent investigation into trends, such as the breakdown of papers by author country or affiliation and by subject area, may reveal more profound insights into the dynamics of this emerging sector.

The concentration of productive writers, led by Dr. David W.M. Chan, and their broad geographic representation highlight the field's relatively focused research output, which may be impacted by variables such as BIM's novelty or restricted funding prospects. The data also indicates the globalization of BIM research, with contributions coming from Hong Kong, Malaysia, Nigeria, and Vietnam.

Furthermore, the data demonstrates the multidisciplinary nature of BIM research, with Engineering dominating the topic areas, particularly Civil Engineering, Computer Science, and Environmental Engineering. This prevalence highlights the importance of engineering disciplines in developing and using BIM technology. Beyond engineering, the enormous contributions from computer science, business, management, accounting, social sciences, and humanities demonstrate BIM's broad impact across multiple disciplines. The most referenced works highlight the critical research that affects the conversation on BIM adoption, particularly on emerging markets, SMEs, and sustainability problems. The worldwide collaboration map and source citation network provide a bird ' s-eye view of countries' collaborative activities with prominent journals, emphasizing common knowledge and research achievements that propel the subject ahead. Overall, this bibliometric analysis not only represents the present state of BIM research but also outlines a pathway for future development exploration and comprehension of the complex landscape of BIM adoption in the construction sector.

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3. Jabatan Pendidikan Politeknik dan Kolej Komuniti (JPPKK), Ministry of Higher Education

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