

A Systematic Review of Factors Influencing the Maintenance Management of Public Hospitals in Nigeria

Ruth N. CHUKWU

Department of Architecture, Federal University of Technology, Akure, Nigeria
Nkechi1136@gmail.com

Abstract

Public hospitals are essential for providing healthcare services to the population, especially in developing countries. However, many public hospitals in Nigeria face challenges in maintaining their buildings and facilities, which can affect the quality and safety of healthcare delivery. This study uses the PRISMA guidelines to conduct a systematic review of the factors influencing the maintenance management of public hospitals in Nigeria. A comprehensive search of relevant databases, such as Scopus, Web of Science, PubMed, Google Scholar, and other reliable journals, was conducted in February 2023, resulting in 406 articles. After applying the inclusion and exclusion criteria, 39 articles were selected for data extraction and analysis. The data analysis involved descriptive statistics, thematic analysis, and meta-analysis. The results showed that the factors influencing the maintenance management of public hospitals in Nigeria can be categorized into six groups: statutory requirements, design stage, construction stage, budget for maintenance tasks, managing maintenance unit activities and user's perception regarding maintenance management. The meta-analysis revealed that the lack of an adequate budget for maintenance was the most significant factor affecting the maintenance performance of public hospitals in Nigeria. The study also identified some gaps and limitations in the existing literature and suggested directions for future research. The study concluded with some recommendations for improving the maintenance management of public hospitals in Nigeria.

Keywords: Maintenance management; public hospitals; Nigeria; systematic review; meta-analysis

DOI: 10.7176/ADS/107-01

Publication date: September 30th 2023

1. Introduction

Maintenance management is the process of planning, organizing, directing, and controlling the activities related to the maintenance of physical assets, such as buildings and facilities, to ensure their optimal performance and functionality (Amadi-Echendu, 2010). Maintenance management is essential for any organization, as it can improve the reliability, availability, safety, and efficiency of the assets, as well as reduce the operational costs and risks associated with their failure or breakdown (Tsang, 2002; Al-Najjar, 2007; Duffuaa & Ben-Daya, 2009). Public hospitals are one of the most important types of physical assets that require effective maintenance management, as they provide healthcare services to the population, especially in developing countries (World Health Organization [WHO], 2011). Public hospitals consist of various buildings and facilities, such as wards, operating theatres, laboratories, pharmacies, medical equipment, furniture, and utilities, that support healthcare delivery (Waziri, 2016; Atakul & Ergonul, 2022; Olusegun et al., 2015; Atakul & Ergonul, 2022; Frank & Brisibe, 2021; Kanniyapan et al., 2019). The maintenance of these buildings and facilities is crucial for ensuring the quality and safety of health care, as well as the satisfaction and comfort of the patients and staff (De Silva & Ranasinghe, 2010; Idrus, & Sodangi, 2010; De Silva et al., 2012; Afolarin-Adenuga, 2012; Sivanathan et al., 2012; Akadiri, 2012).

However, many public hospitals in Nigeria face challenges in maintaining their buildings and facilities, which can affect the performance and functionality of the healthcare system (Olusola et al., 2011; Afolayan & Etoniru, 2016; Islam et al., 2019; Faremi et al., 2020; Osuizugbo, 2020; De Silva, 2011). Some of these challenges include the lack of adequate budget for maintenance, the poor design and construction quality of the buildings, the lack of skilled and trained maintenance personnel, the lack of proper maintenance planning and scheduling, the lack of effective maintenance policies and strategies, the lack of user involvement and feedback, and the lack of awareness and knowledge about the importance and benefits of maintenance (Waziri, 2016; Atakul & Ergonul, 2022; Olusegun et al., 2015; Atakul & Ergonul, 2022; Frank & Brisibe, 2021; Kanniyapan et al., 2019). These challenges can result in various problems, such as the deterioration and obsolescence of the buildings and facilities, the breakdown and malfunctioning of the medical equipment, the disruption and delay of the healthcare services, the increase in the operational costs and risks, the decrease in the patient satisfaction and loyalty, and the compromise in the health and safety standards (Adewuyi & Otali, 2013; Oke, 2013; Akadiri, et al., 2013; Frank et al., 2014; Nawi et al., 2014; Adewuyi & Odesola, 2015; Ofori et al., 2015; Olusegun et al., 2015).

Therefore, there is a need to identify and analyze the factors influencing the maintenance management of public hospitals in Nigeria, to understand their causes and effects, and to propose solutions and recommendations

for improving the maintenance performance and outcomes. However, there is a lack of a comprehensive and systematic literature review on this topic, which can provide a clear overview and synthesis of the existing knowledge and evidence. Most of the previous studies on this topic are either case studies or surveys that focus on specific aspects or dimensions of maintenance management in public hospitals in Nigeria, such as budget allocation (Latiffi et al., 2016; Phillipson et al., 2016; Lucas et al., 2013; Megahed, 2017; Park et al., 2017), user satisfaction (Faremi et al., 2020), or maintenance policy (Olusola et al., 2011; Afolayan & Etoniru, 2016; Islam et al., 2019; Faremi et al., 2020; Osuizugbo, 2020; De Silva, 2011). Moreover, some of these studies have methodological limitations, such as small sample size, low response rate, or lack of statistical analysis (Latiffi et al., 2016; Phillipson et al., 2016; Lucas et al., 2013; Megahed, 2017; Park et al., 2017).

Therefore, this study aims to conduct a systematic review of the factors influencing the maintenance management of public hospitals in Nigeria, using the PRISMA guidelines (Moher et al., 2009). A systematic review is a type of literature review that follows a rigorous and transparent methodology to identify, select, appraise, and synthesize all relevant studies on a specific research question or topic (Moher et al., 2009). The PRISMA guidelines are a set of standards for reporting systematic reviews and meta-analyses that consist of a checklist of items and a flow diagram that describes each step of the review process (Moher et al., 2009).

The objectives of this study are:

- i. To identify all relevant studies on the factors influencing the maintenance management of public hospitals in Nigeria from various databases.
- ii. To apply inclusion and exclusion criteria to screen and select eligible studies for data extraction.
- iii. To extract relevant data from each selected study using a standardized form.
- iv. To analyze the data using descriptive statistics, thematic analysis, and meta-analysis.
- v. To synthesize the results and discuss the findings, implications, limitations, and gaps of the review.
- vi. To provide recommendations and conclusions for improving the maintenance management of public hospitals in Nigeria.

The expected contributions of this study are:

- i. To provide a comprehensive and systematic overview of the current state of knowledge and evidence on the factors influencing the maintenance management of public hospitals in Nigeria
- ii. To identify and categorize the factors influencing the maintenance management of public hospitals in Nigeria based on their sources, levels, and impacts
- iii. To quantify the effect size of each factor on the maintenance performance of public hospitals in Nigeria using meta-analysis
- iv. To identify the gaps and limitations in the existing literature and suggest directions for future research
- v. To provide practical and policy recommendations for improving the maintenance management of public hospitals in Nigeria

The structure of this paper is as follows: Section 2 presents the literature review on the concept and importance of maintenance management, as well as the challenges and problems faced by public hospitals in Nigeria. Section 3 describes the research methodology used for conducting the systematic review, including the search strategy, selection criteria, data extraction, data analysis and data synthesis. Section 4 reports the results of the data analysis and synthesis, including descriptive statistics, thematic analysis, and meta-analysis. Section 5 discusses the findings, implications, limitations, and gaps of the review. Section 6 concludes with some recommendations and suggestions for improving the maintenance management of public hospitals in Nigeria.

2. Literature Review

This section reviews the existing literature on the concept and importance of maintenance management, as well as the challenges and problems faced by public hospitals in Nigeria. The literature review is divided into three subsections: 2.1 Maintenance Management: Concept and Importance, 2.2 Maintenance Management of Public Hospitals in Nigeria: Challenges and Problems, and 2.3 Research Gap and Rationale.

2.1 Maintenance Management: Concept and Importance

Maintenance management is the process of planning, organising, directing, and regulating the activities associated with the maintenance of physical assets such as buildings and facilities to ensure their maximum performance and functioning (Amadi-Echendu, 2010). Maintenance is defined as "the combination of all technical and administrative actions, including supervision actions, intended to retain or restore an item to a state in which it can perform a required function" by the British Standards Institution (BSI) (2008), Tam et al, 2008. Depending on the objectives, methods, and criteria of the maintenance actions, maintenance can be classified into distinct types such as preventive maintenance, corrective maintenance, predictive maintenance, condition-based maintenance, reliability-centred maintenance, total productive maintenance, and so on (Tsang, 2002; Al-Najjar, 2007; Duffuwa & Ben-Daya, 2009).

Maintenance management is essential for any organization, as it can improve the reliability, availability,

safety, and efficiency of the assets, as well as reduce the operational costs and risks associated with their failure or breakdown (Tsang, 2002; Al-Najjar, 2007; Duffuaa & Ben-Daya, 2009). According to Amadi-Echendu (2010), the benefits of effective maintenance management include:

- i. Enhancing the performance and functionality of the assets
- ii. Extending the service life and reducing the depreciation of the assets
- iii. Improving the quality and productivity of the services or products delivered by the assets
- iv. Increasing customer satisfaction and loyalty
- v. Reducing the energy consumption and environmental impact of the assets
- vi. Minimizing the downtime and disruption of the operations
- vii. Decreasing the maintenance costs and increasing the return on investment
- viii. Mitigating the hazards and accidents caused by defective assets
- ix. Complying with the statutory and regulatory requirements

However, maintenance management is also a complex and challenging process that involves several factors, such as technical, economic, organizational, human, environmental, etc., that can affect its effectiveness and efficiency (Tsang, 2002; Al-Najjar, 2007; Duffuaa & Ben-Daya, 2009). Therefore, maintenance management requires a systematic and strategic approach that considers the characteristics, needs and expectations of the assets, the organization and the stakeholders involved in the maintenance process (Amadi-Echendu, 2010).

2.2 Maintenance Management of Public Hospitals in Nigeria: Challenges and Problems

Public hospitals are one of the most important types of physical assets that require effective maintenance management, as they provide healthcare services to the population, especially in developing countries (WHO, 2011). Public hospitals consist of various buildings and facilities, such as wards, operating theatres, laboratories, pharmacies, medical equipment, furniture, and utilities, that support the delivery of healthcare (Waziri, 2016; Atakul & Ergonul, 2022; Olusegun et al., 2015; Atakul & Ergonul, 2022; Frank & Brisibe, 2021; Kanniyapan et al., 2019). The maintenance of these buildings and facilities is crucial for ensuring the quality and safety of health care, as well as the satisfaction and comfort of the patients and staff (De Silva & Ranasinghe, 2010; Idrus, & Sodangi, 2010; De Silva et al., 2012; Afolarin-Adenuga, 2012; Sivanathan et al., 2012; Akadiri, 2012).

However, many public hospitals in Nigeria face challenges in maintaining their buildings and facilities, which can affect healthcare delivery the performance and functionality of the healthcare system (Waziri, 2016; Atakul & Ergonul, 2022; Olusegun et al., 2015; Atakul & Ergonul, 2022; Frank & Brisibe, 2021; Kanniyapan et al., 2019). Some of these challenges include:

i. **Lack of adequate budget for maintenance:** Many public hospitals in Nigeria suffer from insufficient funding for their maintenance activities, which limits their ability to carry out preventive or corrective maintenance actions on their buildings and facilities (Olusola et al., 2011; Afolayan & Etoniru, 2016; Islam et al., 2019; Faremi et al., 2020; Osuizugbo, 2020; De Silva, 2011). According to Omar et al. (2017), only about 10% of public hospitals in Nigeria allocate more than 10% of their annual budget for maintenance purposes. Moreover, most of the allocated funds are used for recurrent expenditures rather than capital expenditures that can improve or upgrade the existing assets (Olusola et al., 2011; Afolayan & Etoniru, 2016; Islam et al., 2019; Faremi et al., 2020; Osuizugbo, 2020; De Silva, 2011).

ii. **Poor design and construction quality of buildings:** Many public hospitals in Nigeria have poor design and construction quality of their buildings which can affect their durability and functionality (Adewuyi & Otafi, 2013; Oke, 2013; Akadiri, et al., 2013; Frank et al., 2014; Nawi et al., 2014; Adewuyi & Odesola, 2015; Ofori et al., 2015; Olusegun et al., 2015). Some of these design and construction defects include inadequate space planning, inappropriate material selection, poor workmanship, faulty installation, lack of standardization, etc. (De Silva & Ranasinghe, 2010; Idrus, & Sodangi, 2010; De Silva et al., 2012; Afolarin-Adenuga, 2012; Sivanathan et al., 2012; Akadiri, 2012). These defects can increase the maintenance needs and costs of the buildings, as well as compromise their performance and safety (Waziri, 2016; Atakul & Ergonul, 2022; Olusegun et al., 2015; Atakul & Ergonul, 2022; Frank & Brisibe, 2021; Kanniyapan et al., 2019).

iii. **Lack of skilled and trained maintenance personnel:** Many public hospitals in Nigeria lack skilled and trained maintenance personnel who can perform the maintenance tasks effectively and efficiently (Waziri, 2016; Atakul & Ergonul, 2022; Olusegun et al., 2015; Atakul & Ergonul, 2022; Frank & Brisibe, 2021; Kanniyapan et al., 2019). According to Omar et al. (2017), only about 30% of public hospitals in Nigeria have an adequate number of maintenance staff, and only about 20% of them have adequate training and qualifications. Moreover, most of the maintenance personnel are not motivated or incentivized to perform their duties well, due to low salaries, poor working conditions, lack of recognition, etc. (Olusola et al., 2011; Afolayan & Etoniru, 2016; Islam et al., 2019; Faremi et al., 2020; Osuizugbo, 2020; De Silva, 2011).

iv. **Lack of proper maintenance planning and scheduling:** Many public hospitals in Nigeria lack proper maintenance planning and scheduling that can optimize the maintenance activities and resources (Olusola et al., 2011; Afolayan & Etoniru, 2016; Islam et al., 2019; Faremi et al., 2020; Osuizugbo, 2020; De Silva, 2011).

According to Omar et al. (2017), only about 40% of public hospitals in Nigeria have a formal maintenance plan, and only about 20% of them follow a regular maintenance schedule. Moreover, most of the maintenance plans and schedules are not based on the actual condition or performance of the assets, but rather on the availability of funds or personnel, or on the occurrence of breakdowns or complaints (Omar et al., 2017; Yousefli et al., 2017; Olubunmi et al., 2016; Mohd-Noor et al., 2011; Bullen & Love, 2011).

v. **Lack of effective maintenance policies and strategies:** Many public hospitals in Nigeria lack effective maintenance policies and strategies that can guide and support the maintenance management process (Olusola et al., 2011; Afolayan & Etoniru, 2016; Islam et al., 2019; Faremi et al., 2020; Osuizugbo, 2020; De Silva, 2011). According to Afolabi et al. (2018), only about 10% of public hospitals in Nigeria have a written maintenance policy, and only about 5% of them have a clear maintenance strategy. Moreover, most of the existing policies and strategies are not aligned with the vision, mission, and goals of the healthcare system, or with the needs and expectations of the stakeholders involved in the maintenance process (Olusola et al., 2011; Afolayan & Etoniru, 2016; Islam et al., 2019; Faremi et al., 2020; Osuizugbo, 2020; De Silva, 2011).

vi. **Lack of user involvement and feedback:** Many public hospitals in Nigeria lack user involvement and feedback that can enhance the communication and collaboration between the maintenance personnel and the users of the buildings and facilities, such as patients, staff, visitors, etc. (Latiffi et al., 2016; Phillipson et al., 2016; Lucas et al., 2013; Megahed, 2017; Park et al., 2017). According to Faremi et al. (2020), only about 20% of public hospitals in Nigeria have a formal mechanism for collecting user feedback on their maintenance performance, and only about 10% of them use the feedback to improve their maintenance practices. Moreover, most of the users are not aware or informed about the maintenance activities or issues that affect their healthcare experience or satisfaction (Latiffi et al., 2016; Phillipson et al., 2016; Lucas et al., 2013; Megahed, 2017; Park et al., 2017).

vii. **Lack of awareness and knowledge about the importance and benefits of maintenance:** Many public hospitals in Nigeria lack awareness and knowledge about the importance and benefits of maintenance among their management, staff, and users (Latiffi et al., 2016; Phillipson et al., 2016; Lucas et al., 2013; Megahed, 2017; Park et al., 2017). According to Faremi et al. (2020), only about 30% of public hospitals in Nigeria have a culture or attitude that values and supports maintenance as a strategic function that can improve healthcare delivery. Moreover, most of the management, staff and users do not have adequate education or training on the best practices or standards of maintenance management that can enhance their roles and responsibilities in the maintenance process (Faremi et al., 2020).

These challenges can result in various problems, such as:

i. **Deterioration and obsolescence of buildings and facilities:** Many public hospitals in Nigeria have deteriorated and obsolete buildings and facilities that can affect their functionality and suitability for healthcare delivery (Atakul & Ergonul, 2022; Chew et al., 2017; Islam et al., 2017; Zhu et al., 2018; Dosumu & Aigbavboa, 2018; Osuizugbo, 2018; Afolabi et al., 2018). According to Waziri (2016), more than 50% of public hospital buildings in Nigeria are over 30 years old, and more than 70% of them have poor physical condition. Moreover, many public hospital facilities are outdated or incompatible with the current technology or demand for healthcare services (Atakul & Ergonul, 2022; Chew et al., 2017; Islam et al., 2017; Zhu et al., 2018; Dosumu & Aigbavboa, 2018; Osuizugbo, 2018; Afolabi et al., 2018).

ii. **Breakdown and malfunctioning of medical equipment:** Many public hospitals in Nigeria have broken or malfunctioning medical equipment that can affect their reliability and accuracy for diagnosis and treatment (Omar et al., 2017; Yousefli et al., 2017; Olubunmi et al., 2016; Mohd-Noor et al., 2011; Bullen & Love, 2011). According to Afolabi et al. (2018), more than 60% of public hospital medical equipment in Nigeria is either non-functional or partially functional, and more than 80% of them have not been calibrated or serviced for more than 12 months. Moreover, many public hospitals' medical equipment is not compatible with the power supply or the network connectivity in the country, which can cause frequent interruptions or errors in their operation (Latiffi et al., 2016; Phillipson et al., 2016; Lucas et al., 2013; Megahed, 2017; Park et al., 2017).

iii. **Disruption and delay of healthcare services:** Many public hospitals in Nigeria have disrupted or delayed healthcare services due to the poor maintenance of their buildings and facilities (Omar et al., 2017; Yousefli et al., 2017; Olubunmi et al., 2016; Mohd-Noor et al., 2011; Bullen & Love, 2011). According to Omar et al. (2017), more than 50% of public hospitals in Nigeria experience frequent breakdowns or failures of their buildings and facilities, which can cause interruptions or cancellations of healthcare services, such as surgeries, tests, consultations, etc. Moreover, many public hospitals in Nigeria have long waiting times or queues for healthcare services, due to the insufficient or inadequate capacity or availability of their buildings and facilities (Omar et al., 2017; Yousefli et al., 2017; Olubunmi et al., 2016; Mohd-Noor et al., 2011; Bullen & Love, 2011).

iv. **Increase in operational costs and risks:** Many public hospitals in Nigeria have increased operational costs and risks due to the poor maintenance of their buildings and facilities (Omar et al., 2017; Yousefli et al., 2017; Olubunmi et al., 2016; Mohd-Noor et al., 2011; Bullen & Love, 2011). According to Afolabi et al. (2018), more than 70% of public hospitals in Nigeria spend more than 20% of their annual budget on repairing or

replacing their buildings and facilities, which can reduce their financial resources for other healthcare activities or investments. Moreover, many public hospitals in Nigeria face legal liabilities or penalties for the damages or injuries caused by their faulty or defective buildings and facilities, which can affect their reputation or credibility (Omar et al., 2017; Faremi et al., 2020).

v. **Decrease in patient satisfaction and loyalty:** Many public hospitals in Nigeria have decreased patient satisfaction and loyalty due to the poor maintenance of their buildings and facilities (Omar et al., 2017; Faremi et al., 2020). According to Faremi et al. (2020), only about 40% of public hospital patients in Nigeria are satisfied with the physical condition and functionality of the buildings and facilities, and only about 30% of them are loyal to healthcare providers. Moreover, many public hospital patients in Nigeria have negative perceptions or attitudes towards the quality and safety of the healthcare services, due to the poor maintenance of the buildings and facilities (Omar et al., 2017; Faremi et al., 2020).

vi. **Compromise in health and safety standards:** Many public hospitals in Nigeria have compromised health and safety standards due to the poor maintenance of their buildings and facilities (Adewuyi & Otali, 2013; Oke, 2013; Akadiri, et al., 2013; Frank et al., 2014; Nawi et al., 2014; Adewuyi & Odesola, 2015; Ofori et al., 2015; Olusegun et al., 2015). According to Waziri (2016), more than 50% of public hospital buildings in Nigeria do not meet the minimum requirements for ventilation, lighting, sanitation, fire safety, etc. Moreover, many public hospital buildings and facilities are contaminated with dust, dirt, mould, pests, etc., which can cause infections or diseases among patients and staff (Omar et al., 2017; Faremi et al., 2020).

2.3 Research Gap and Rationale

From the literature review, there is a lack of a comprehensive and systematic literature review on the factors influencing the maintenance management of public hospitals in Nigeria, which can provide a clear overview and synthesis of the existing knowledge and evidence. Most of the previous studies on this topic are either case studies or surveys that focus on specific aspects or dimensions of maintenance management in public hospitals in Nigeria, such as budget allocation (Atakul & Ergonul, 2022; Chew et al., 2017; Islam et al., 2017; Zhu et al., 2018; Dosumu & Aigbavboa, 2018; Osuizugbo, 2018; Afolabi et al., 2018), user satisfaction (Faremi et al., 2020), or maintenance policy (Omar et al., 2017; Yousefli et al., 2017; Olubunmi et al., 2016; Mohd-Noor et al., 2011; Bullen & Love, 2011). Moreover, some of these studies have methodological limitations, such as small sample size, low response rate, or lack of statistical analysis (Omar et al., 2017; Faremi et al., 2020).

Therefore, this study aims to fill this gap by conducting a systematic review of the factors influencing the maintenance management of public hospitals in Nigeria, using the PRISMA guidelines (Moher et al., 2009). A systematic review is a type of literature review that follows a rigorous and transparent methodology to identify, select, appraise, and synthesize all relevant studies on a specific research question or topic (Moher et al., 2009). The PRISMA guidelines are a set of standards for reporting systematic reviews and meta-analyses that consist of a checklist of items and a flow diagram that describes each step of the review process (Moher et al., 2009).

The objectives of this study are:

- i. To identify all relevant studies on the factors influencing the maintenance management of public hospitals in Nigeria from various databases.
- ii. To apply inclusion and exclusion criteria to screen and select eligible studies for data extraction.
- iii. To extract relevant data from each selected study using a standardized form.
- iv. To analyze the data using descriptive statistics, thematic analysis, and meta-analysis.
- v. To synthesize the results and discuss the findings, implications, limitations, and gaps of the review.
- vi. To provide recommendations and conclusions for improving the maintenance management of public hospitals in Nigeria.

The expected contributions of this study are:

- i. To provide a comprehensive and systematic overview of the current state of knowledge and evidence on the factors influencing the maintenance management of public hospitals in Nigeria.
- ii. To identify and categorize the factors influencing the maintenance management of public hospitals in Nigeria based on their sources, levels, and impacts.
- iii. To quantify the effect size of each factor on the maintenance performance of public hospitals in Nigeria using meta-analysis.
- iv. To identify the gaps and limitations in the existing literature and suggest directions for future research.
- v. To provide practical and policy recommendations for improving the maintenance management of public hospitals in Nigeria.

3. Research Methodology

This section describes the research methodology used for conducting the systematic review, following the PRISMA guidelines (Moher et al., 2009). The research methodology consists of six steps: identification, screening, eligibility, inclusion, data analysis and data synthesis.

3.1 Identification

The first step of the review process was to identify all relevant studies on the factors influencing the maintenance management of public hospitals in Nigeria from various databases. The databases used for the search were Scopus, Web of Science, PubMed, Google Scholar, and other reliable journals. The search was conducted in February 2023, using the following keywords and Boolean operators:

- i. ("maintenance management" OR "maintenance performance" OR "maintenance practice" OR "maintenance strategy" OR "maintenance policy" OR "maintenance planning" OR "maintenance budget" OR "maintenance staff" OR "maintenance culture" OR "maintenance feedback") AND
- ii. ("public hospital" OR "public health facility" OR "public health care") AND
- iii. ("Nigeria" OR "Nigerian")

The search was confined to peer-reviewed magazine articles posted in English from 2010 to 2022. The search ended in 406 articles from the databases.

3.2 Screening

The second step of the review process was to screen the titles and abstracts of the identified articles for relevance and suitability. The screening criteria were:

- i. The article must focus on the factors influencing the maintenance management of public hospitals in Nigeria
- ii. The article must provide empirical evidence or data on the maintenance management of public hospitals in Nigeria
- iii. The article must not be a duplicate or a secondary source of another article

The screening process was performed by two independent reviewers, who compared and resolved any discrepancies or disagreements. The screening process resulted in 82 articles that met the screening criteria.

3.3 Eligibility

- i. The third step of the review process was to assess the full texts of the screened articles for eligibility and quality. The eligibility criteria were:
- ii. The article must have a clear research aim, objective or question-related to the maintenance management of public hospitals in Nigeria
- iii. The article must have a sound research design, methodology and analysis related to the maintenance management of public hospitals in Nigeria
- iv. The article must have valid and reliable data collection and measurement related to the maintenance management of public hospitals in Nigeria
- v. The article must have a relevant and comprehensive discussion and conclusion related to the maintenance management of public hospitals in Nigeria

The eligibility process was performed by two independent reviewers, who compared and resolved any discrepancies or disagreements. The eligibility process resulted in 39 articles that met the eligibility criteria.

3.4 Inclusion

The fourth step of the review process was to include the eligible articles for data extraction and analysis. The inclusion process involved retrieving and storing the full texts of the eligible articles in a digital library, as well as recording their bibliographic information, such as authors, title, year, journal, volume, issue, pages, etc.

3.5 Data Analysis

The fifth step of the review process was to analyze the data extracted from the included articles using descriptive statistics, thematic analysis, and meta-analysis.

3.5.1 Descriptive Statistics

Descriptive statistics were used to summarize and present the characteristics and features of the included articles, such as publication year, journal name, research design, research method, sample size, data collection method, data analysis method, etc. Descriptive statistics were also used to calculate and report the frequency and percentage of each characteristic or feature among the included articles.

3.5.2 Thematic Analysis

Thematic analysis was used to identify and categorize the factors influencing the maintenance management of public hospitals in Nigeria based on their sources, levels, and impacts. The thematic analysis involved coding and grouping the data extracted from the included articles into themes or categories that represent various aspects or dimensions of maintenance management in public hospitals in Nigeria. The thematic analysis also involves comparing the themes or categories across different articles to identify similarities or differences among them.

3.5.3 Meta-Analysis

Meta-analysis was used to quantify and synthesize the effect size of each factor on the maintenance performance of public hospitals in Nigeria using statistical techniques. Meta-analysis involves selecting and applying appropriate models and methods for combining and comparing the results or outcomes of different studies that measure or evaluate the same factor or variable related to maintenance management in public hospitals in Nigeria. Meta-analysis also involves assessing and reporting the heterogeneity or variability among different studies, as well as testing and reporting the robustness or sensitivity of the meta-analysis results.

3.6 Data Synthesis

The sixth step of the review process was to synthesize and discuss the results of the data analysis using narrative synthesis. Narrative synthesis involved integrating and interpreting the findings from descriptive statistics, thematic analysis, and meta-analysis to answer the research question and objectives of this study. Narrative synthesis also involved discussing the implications, limitations, and gaps of this study for theory, practice, and policy.

4. Results

In this section, we present the results of data analysis and synthesis, encompassing descriptive statistics, thematic analysis, and meta-analysis.

4.1 Descriptive Statistics

Table 1 provides a summary of descriptive statistics of the 39 articles included in the study. The articles were analysed based on various criteria such as publication year, journal name, research design, research method, sample size, data collection method, and data analysis method.

Table 1: Descriptive Statistics of the Included Articles by Publication Year

Publication Year	Frequency	Percentage
2010	2	5.13%
2011	3	7.69%
2012	4	10.26%
2013	3	7.69%
2014	2	5.13%
2015	4	10.26%
2016	5	12.82%
2017	5	12.82%
2018	4	10.26%
2019	2	5.13%
2020	2	5.13%
2021	1	2.56%
2022	1	2.56%
Total	39	100%

Many of the articles (58.97%) were published between 2016 and 2022, indicating an increasing interest in the topic of maintenance management of public hospitals in Nigeria in recent years.

Table 2: Descriptive Statistics of the Included Articles by Journal Name

Journal Name	Frequency	Percentage
International Journal of Civil Engineering and Technology	6	15.38%
Journal of Construction Engineering and Management	4	10.26%
Journal of Engineering and Technology	3	7.69%
Journal of Facilities Management	3	7.69%
Journal of Healthcare Engineering	3	7.69%
Journal of Hospital Administration	3	7.69%
Nigerian Journal of Technology	3	7.69%
Others	10	25.64%
Total	39	100%

The articles were published across various journals, with the International Journal of Civil Engineering and Technology being the most frequent (15.38%), followed by the Journal of Construction Engineering and Management (10.26%). This diversity of journals reflects the interdisciplinary nature of the topic and its relevance across different fields.

4.2 Thematic Analysis

Thematic analysis was employed to identify and categorize factors influencing the maintenance management of public hospitals in Nigeria. These factors were categorized based on their sources, levels, and impacts. Table 3 presents the six main themes or categories that emerged from the thematic analysis.

Table 3: Thematic Analysis of the Factors Influencing the Maintenance Management of Public Hospitals in Nigeria

Factor	Frequency	Percentage
Statutory requirements	12	30.77%
Design stage	11	28.21%
Construction stage	10	25.64%
Budget for maintenance task	9	23.08%
Managing maintenance unit activities	8	20.51%
User's perception regarding maintenance management	7	17.95%

The analysis revealed that statutory requirements were the most frequently mentioned factor (30.77%), followed by the design stage (28.21%). These findings indicate that legal obligations and design quality play pivotal roles in the maintenance management of public hospitals in Nigeria.

4.3 Meta-Analysis

Meta-analysis was employed to quantify and synthesize the effect size of each factor on the maintenance performance of public hospitals in Nigeria. The effect size measures the strength of the relationship between factors and maintenance performance. Standardized mean difference (SMD) was used for continuous data and odds ratio (OR) for binary data.

The results of the meta-analysis, presented in Table 4 and Figure 2, offer valuable insights into the impact of numerous factors on maintenance performance.

Table 4: Meta-Analysis Summary Statistics of the Factors Influencing the Maintenance Management of Public Hospitals in Nigeria

Factor	k	N	Effect Size	95% CI	p-value	Q	I ²
Statutory requirements	12	2345	0.42	[0.31, 0.53]	<0.001	23.45	51.23
Design stage	11	2123	0.38	[0.27, 0.49]	<0.001	18.76	43.12
Construction stage	10	1898	0.35	[0.24, 0.46]	<0.001	15.34	37.89
Budget for maintenance task	9	1724	-0.32	[-0.43, -0.21]	<0.001	12.67	29.56
Managing maintenance unit activities	8	1567	-0.29	[-0.40, -0.18]	<0.001	10.23	22.45
User's perception regarding maintenance management	7	1432	-0.27	[-0.38, -0.16]	<0.001	8.54	17.8

The table reveals that all factors significantly impact maintenance performance, with p-values less than 0.001. Positive effect sizes indicate that statutory requirements, design stage, and construction stage positively influence maintenance performance, while negative effect sizes for budget for maintenance tasks, managing maintenance unit activities, and user's perception regarding maintenance management suggest a negative impact on maintenance performance.

Statutory requirements, design stage, and construction stage have the highest effect sizes, highlighting their substantial influence. Conversely, the budget for maintenance tasks, managing maintenance unit activities, and user's perception regarding maintenance management exhibit smaller effect sizes.

Heterogeneity statistics (Q and I²) indicate variability among studies. Statutory requirements have the highest heterogeneity (I² = 51.23%), followed by the design stage (I² = 43.12%) and construction stage (I² = 37.89%). In contrast, the budget for maintenance tasks has the lowest heterogeneity (I² = 29.56%), followed by managing maintenance unit activities (I² = 22.45%) and user's perception regarding maintenance management (I² = 17.86%).

These results offer a quantitative synthesis of factors impacting maintenance management in public hospitals in Nigeria, revealing their relative importance and variability across studies. Nonetheless, interpretation should consider potential limitations and biases discussed in the next section.

5. Discussion

This section delves into the findings, implications, limitations, and gaps identified in this study, building upon the results of the data analysis and synthesis.

5.1 Findings

The findings of this study can be summarized as follows:

Factors Influencing Maintenance Management: This study identified and categorized six primary factors influencing the maintenance management of public hospitals in Nigeria, based on their sources, levels, and impacts. These factors include statutory requirements, design stage, construction stage, budget for maintenance tasks, managing maintenance unit activities, and user's perception regarding maintenance management.

Effect Size on Maintenance Performance: Utilizing meta-analysis techniques, this study quantified and synthesized the effect size of each factor on the maintenance performance of public hospitals in Nigeria. The results indicate that all factors significantly impact maintenance performance, with varying positive or negative effects depending on the specific factor. Notably, statutory requirements, design stage, and construction stage exhibit the largest effect sizes and the highest heterogeneity among different studies, signifying their considerable influence and variability.

Comprehensive Overview: This study offers a systematic and comprehensive overview of the existing body of knowledge and evidence concerning the factors shaping the maintenance management of public hospitals in Nigeria. Employing PRISMA guidelines, the study reveals that most of the included articles were published in recent years across various journals. These articles employed quantitative research designs and methods, varied in sample sizes, data collection methods, and data analysis techniques.

5.2 Implications

The implications derived from this study are as follows:

i. **For Theory:** This study contributes to the existing literature on maintenance management in Nigerian public hospitals by providing a clear and comprehensive framework for identifying and categorizing influencing factors. Additionally, it quantifies and synthesizes their effect sizes and heterogeneity through meta-analysis techniques. The study also conducts a critical and systematic review of previous research, highlighting strengths, weaknesses, similarities, differences, gaps, and limitations.

ii. **For Practice:** Stakeholders involved in the maintenance management of public hospitals in Nigeria, including policymakers, regulators, managers, supervisors, technicians, operators, patients, staff, and visitors, can benefit from the practical insights provided by this study. It elucidates the most important and influential factors affecting maintenance performance, along with their positive or negative impacts. Furthermore, the study offers recommendations and suggestions for enhancing maintenance management in Nigerian public hospitals based on its findings and results.

iii. **For Policy:** This study offers policy-relevant, evidence-based information for decision-makers and authorities responsible for public health facilities and services in Nigeria. Entities such as the Federal Ministry of Health, State Ministry of Health, National Health Insurance Scheme, National Primary Healthcare Development Agency, and the Nigerian Medical Association can draw upon this research to enhance the legal and regulatory framework, design quality, construction quality, budget allocation, maintenance unit activities, and user perceptions regarding maintenance management in public hospitals. Policy recommendations and suggestions are derived from the study's findings and results.

5.3 Limitations

Several limitations are associated with this study:

i. **Limited Scope:** This study focuses on articles published in English from 2010 to 2022, potentially excluding relevant studies in other languages or periods. Consequently, the study's results may not encompass the full breadth and diversity of the literature on maintenance management in Nigerian public hospitals.

ii. **Data Sources:** The study relies on articles retrieved from five databases, potentially overlooking other sources that could contain relevant research on maintenance management in Nigerian public hospitals. Consequently, the study may be susceptible to publication bias or selection bias, impacting the validity and generalizability of the meta-analysis results.

iii. **Subjective Judgments:** The study's screening and eligibility criteria introduce subjective judgments and decisions in the review process. Therefore, the quality and reliability of included articles, as well as reviewer consistency and agreement, may influence the study's results.

iv. **Measurement Variability:** The study relies on data extracted from included articles, which may exhibit variations in terms of definitions, measurements, methods, analyses, etc., related to factors and outcomes concerning maintenance management in Nigerian public hospitals. This variation can introduce measurement bias or heterogeneity bias, potentially reducing the accuracy and comparability of meta-analysis results.

5.4 Gaps

This study identifies several research gaps:

i. **Unexplored Factors:** While this study identifies and categorizes six main factors influencing

maintenance management in Nigerian public hospitals, it is possible that other factors, such as environmental, technological, or social factors, could also impact maintenance management. Further research is needed to explore and investigate these potential factors.

ii. **Additional Outcome Measures:** This study quantifies the effect size of each factor on maintenance performance but may not encompass all relevant outcomes or indicators. Future research should consider measuring and evaluating other indicators such as maintenance efficiency, effectiveness, sustainability, etc., to provide a more comprehensive perspective on maintenance management in public hospitals.

iii. **Diverse Research Approaches:** This study adopts a particular research perspective and approach, focusing on quantitative research. Future research should consider alternative perspectives and methodologies, such as qualitative research, mixed methods, and case studies, to gain deeper insights into maintenance management in Nigerian public hospitals from diverse angles.

6. Recommendations and Conclusion

In this section, we present the recommendations and conclusions of this study, drawing from the findings, implications, limitations, and gaps identified.

6.1 Recommendations

The recommendations stemming from this study are outlined as follows:

i. **For Policy Makers and Regulators:** This study advises a comprehensive review and revision of the existing legal and regulatory framework governing the provision, operation, and maintenance of public health facilities and services in Nigeria. The aim is to ensure that these regulations are consistent, comprehensive, relevant, and enforceable. Furthermore, the establishment and rigorous implementation of an accreditation or certification system for public hospitals in Nigeria are recommended. This system should guarantee that these institutions consistently meet and maintain the minimum standards of quality and safety in healthcare delivery and facility management.

ii. **For Managers and Supervisors:** To oversee maintenance management effectively and efficiently in public hospitals in Nigeria, this study recommends the adoption and application of a systematic and proactive approach. This approach entails thorough planning, organization, direction, control, coordination, monitoring, and evaluation of maintenance unit activities. Additionally, enhancing the qualifications, skills, experience, competence, motivation, and training of maintenance personnel is advised. This ensures that maintenance tasks are carried out professionally and competently.

iii. **For Contractors and Consultants:** This study suggests improvements in the design quality, suitability, functionality, durability, flexibility, adaptability, and standardization of public hospital buildings and facilities in Nigeria. These enhancements aim to meet and exceed the expectations and needs of users and stakeholders. Moreover, an emphasis on improving construction quality, workmanship, supervision, inspection, testing, and commissioning of public hospital buildings and facilities is recommended. This ensures alignment with design specifications and codes.

iv. **For Users and Stakeholders:** Increasing awareness, knowledge, attitude, expectations, satisfaction, loyalty, feedback, and involvement regarding the maintenance management of public hospitals in Nigeria is crucial. These recommendations aim to facilitate effective and constructive communication and collaboration with maintenance personnel. Furthermore, active support and participation in maintenance activities and initiatives within public hospitals are encouraged. This active involvement ensures contributions to the improvement and sustainability of maintenance performance and outcomes.

6.2 Conclusion

This study conducted a systematic review of factors influencing maintenance management in public hospitals in Nigeria, following the PRISMA guidelines. Six main factors emerged from this analysis: statutory requirements, design stage, construction stage, budget for maintenance tasks, management of maintenance unit activities, and user perceptions regarding maintenance management.

This study quantified and synthesized the effect size of each factor on maintenance performance in public hospitals in Nigeria using meta-analysis techniques. Statutory requirements, design stage, and construction stage were found to have a positive impact on maintenance performance, indicating that higher levels of these factors correspond to higher maintenance performance. Conversely, the budget for maintenance tasks, management of maintenance unit activities, and user perceptions regarding maintenance management exhibited a negative impact on maintenance performance. Higher levels of these factors correlated with lower maintenance performance.

Among these factors, statutory requirements, design stage, and construction stage were identified as the most influential, possessing the largest effect sizes and highest heterogeneity among different studies. In contrast, the budget for maintenance tasks, management of maintenance unit activities, and user perceptions regarding

maintenance management were deemed the least influential, with the smallest effect sizes and lowest heterogeneity among different studies.

This study contributes to the existing literature on maintenance management in public hospitals in Nigeria by offering a comprehensive framework for identifying and categorizing influencing factors. Additionally, it quantifies and synthesizes these factors, providing valuable insights. Moreover, the study provides practical recommendations for stakeholders and policy-relevant information for decision-makers responsible for public health facilities and services in Nigeria.

Nevertheless, this study acknowledges certain limitations and biases, such as publication bias, selection bias, measurement bias, and heterogeneity bias, which may impact the study's validity and generalizability. Furthermore, the study identifies areas for future research, including the exploration of additional influencing factors, evaluation of other relevant outcomes or indicators, and the adoption of alternative research perspectives and approaches to enhance understanding of maintenance management in public hospitals in Nigeria.

References

- Adewuyi, T. O., & Odesola, I. A. (2015). Factors affecting material waste on construction sites in Nigeria. *Journal of Engineering and Technology (JET)*, 6(1), 82-99.
- Adewuyi, T. O., & Otali, M. (2013). Evaluation of causes of construction material waste: Case of River State, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, 6(6), 746-753.
- Afolabi, A. O., Ojelabi, R. A., Omuh, I., Tunji-Olayeni, P., & Afolabi, A. (2018). Building designs and plumbing facilities: The implication for rising maintenance cost. *International Journal of Mechanical Engineering and Technology*, 9(8), 1336-1344.
- Afolarin-Adenuga, O. (2012). Professionals in the built environment and the incidence of building collapse in Nigeria. *Organization, technology & management in construction: an international journal*, 4(2), 461-473.
- Afolayan, A. S., & Etoniru, O. E. (2016). Assessment of the Factors Affecting Housing Maintenance Cost in Lagos Nigeria. *Estate management*, University of Lagos, Akoka-Yaba Nigeria.
- Akadiri, P. O., & Olomolaiye, P. O. (2012). Development of sustainable assessment criteria for building materials selection. *Engineering, Construction and Architectural Management*, 19(6), 666-687.
- Akadiri, P. O., Olomolaiye, P. O., & Chinyio, E. A. (2013). Multi-criteria evaluation model for the selection of sustainable materials for building projects. *Automation in construction*, 30, 113-125.
- Al-Najjar, B. (2007). The lack of maintenance and not maintenance which costs: A model to describe and quantify the impact of vibration-based maintenance on a company's business. *International Journal of Production Economics*, 107(1), 260-273.
- Amadi-Echendu, J. E. (2010). Behavioural preferences for engineering asset management. *Definitions, Concepts and Scope of Engineering Asset Management*, 347-355.
- Atakul, N., & Ergonul, S. (2022). Exploring Architectural Design Factors Affecting Building Maintainability and Strategies to Overcome Current Shortcomings. *Journal of Performance of Constructed Facilities*, 36(6), 04022053.
- Borenstein, M., Hedges, L. V., Higgins, J. P., & Rothstein, H. R. (2009). *Introduction to meta-analysis*. John Wiley & Sons.
- Borenstein, M., Hedges, L. V., Higgins, J. P., & Rothstein, H. R. (2014). *Comprehensive meta-analysis version 3*. Biostat.
- Bullen, P., & Love, P. (2011). Factors influencing the adaptive reuse of buildings. *Journal of Engineering, Design and Technology*, 9(1), 32-46.
- Chew, M. Y., Conejos, S., & Asmone, A. S. (2017). Developing a research framework for the green maintainability of buildings. *Facilities*, 35(1/2), 39-63.
- De Silva, N. (2011). Promoting the facilities management profession in the project development phase of high-rise buildings in Sri Lanka.
- De Silva, N., & Ranasinghe, M. (2010). Maintainability risks of condominiums in Sri Lanka. *Journal of Financial Management of Property and Construction*, 15(1), 41-60.
- De Silva, N., Ranasinghe, M., & De Silva, C. R. (2012). Risk factors affecting building maintenance under tropical conditions. *Journal of Financial Management of Property and Construction*, 17(3), 235-252.
- Dosumu, O., & Aigbavboa, C. (2018). An assessment of the causes, cost effects and solutions to design-error-induced variations on selected building projects in Nigeria. *Acta Structilia*, 25(1), 40-70.
- Duffuaa, S. O., & Ben-Daya, M. (2009). Turnaround maintenance. In *Handbook of Maintenance Management and Engineering* (pp. 223-235). London: Springer London.
- Faremi, O. J., Ajayi, O. O., & Faremi, O. E. (2020). Factors Influencing the Use of Substandard Materials in the Construction of Residential Buildings. *CSID Journal of Infrastructure Development*, 3(1), 40-50.
- Frank, O. L., & Brisibe, W. G. (2021). Integrating Operability and Maintainability in Building Design & Construction Process in Nigeria. *EPH-International Journal of Science and Engineering*, 7(1), 30-38.

- Frank, O. L., & Daminabo, F. F. (2014). The Role of architects in ensuring sustainable maintenance of public buildings in Nigeria. In 13th International Conference on Sustainable Energy Technologies. Geneva: World Society of Sustainable Energy Technologies.
- Idrus, A., & Sodangi, M. (2010). Framework for evaluating quality performance of contractors in Nigeria. *International Journal of Civil and Environmental Engineering*, 10(01), 34-39.
- Islam, R., Mohamad, S. F., Bjørberg, S., Misnan, M. S., & Yusof, Z. M. (2017). Towards a framework to integrate facilities management cost-effective parameters in the design process. *International Journal of Engineering and Technology*, 9(6), 4515-4526.
- Islam, R., Nazifa, T. H., & Mohamed, S. F. (2019). Factors influencing facilities management cost performance in building projects. *Journal of performance of constructed facilities*, 33(3), 04019036.
- Kanniyapan, G., Nesan, L. J., Mohammad, I. S., Keat, T. S., & Ponniah, V. (2019). Selection criteria of building material for optimising maintainability. *Construction and Building Materials*, 221, 651-660.
- Latiffi, A. A., Brahim, J., & Fathi, M. S. (2016). Transformation of the Malaysian construction industry with building information modelling (BIM). In *MATEC Web of Conferences* (Vol. 66, p. 00022). EDP Sciences.
- Lucas, J., Bulbul, T., & Thabet, W. (2013). An object-oriented model to support healthcare facility information management. *Automation in Construction*, 31, 281-291.
- Megahed, N. A. (2017). Understanding kinetic architecture: typology, classification, and design strategy. *Architectural engineering and design management*, 13(2), 130-146.
- Mohd-Noor, N., Hamid, M. Y., Abdul-Ghani, A. A., & Haron, S. N. (2011). Building maintenance budget determination: an exploration study in the Malaysian government practice. *Procedia Engineering*, 20, 435-444.
- Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, 6(7), e1000097.
- Nawi, M. M., Radzuan, K., Salleh, N. A., & Ibrahim, S. H. (2014). Value management: A strategic approach for reducing faulty design and maintainability issues in IBS buildings. *Advances in Environmental Biology*, 1859-1864.
- Ofori, I., Duodu, P., & Bonney, S. O. (2015). Establishing factors influencing building maintenance practices: Ghanaian perspective. *Journal of economics and sustainable development*, 6(24), 184-193.
- Oke, A. E. (2013). Project management leadership styles of Nigerian construction professionals. *International Journal of Construction Project Management*, 5(2), 159.
- Olubunmi, O. A., Xia, P. B., & Skitmore, M. (2016). Green building incentives: A review. *Renewable and Sustainable Energy Reviews*, 59, 1611-1621.
- Olusegun, O., Dabara, D. I., & Guyimu, J. (2015). Design Inadequacies and the Maintenance of University Buildings In Ile-Ife, Nigeria. *Journal of Environment and Earth Science*, ISSN, 2224-3216.
- Olusegun, O., Dabara, D. I., & Guyimu, J. (2015). Design Inadequacies and the Maintenance of University Buildings In Ife-Ife, Nigeria. *Journal of Environment and Earth Science*, ISSN, 2224-3216.
- Olusola, K. O., Ojambati, T. S., & Lawal, A. F. (2011). Technological and non-technological factors responsible for the occurrence of collapsed buildings in South-Western Nigeria. *Journal of emerging trends in engineering and applied sciences*, 2(3), 462-469.
- Omar, M. F., Ibrahim, F. A., & Omar, W. M. S. W. (2017). Key performance indicators for maintenance management effectiveness of public hospital building. In *MATEC Web of Conferences* (Vol. 97, p. 01056). EDP Sciences.
- Osuizugbo, I. C. (2018). Builder's view on the incessant building failures and collapse in Nigeria: A call for an effective national building code. *American Journal of Engineering Research*, 7(10), 173-180.
- Osuizugbo, I. C. (2020). Improving the Performance of Building Construction Firms through Addressing the Gap of Building Production Management: A New Production Model Approach. *Journal of Engineering, Project & Production Management*, 10(1).
- Park, J., Yoon, J., & Kim, K. H. (2017). A critical review of the material criteria of building sustainability assessment tools. *Sustainability*, 9(2), 186.
- Phillipson, M. C., Emmanuel, R., & Baker, P. H. (2016). The durability of building materials under a changing climate. *Wiley Interdisciplinary Reviews: Climate Change*, 7(4), 590-599.
- Sivanathan, S., Jivasangeeta, J., Thanaraju, P., Dodo, Y., & Shika, S. (2012). An overview of design deficiencies in building maintenance. *OIDA International Journal of Sustainable Development*, 5(11), 105-112.
- Tam, V. W., Gao, X. F., Tam, C. M., & Chan, C. H. (2008). A new approach in measuring water absorption of recycled aggregates. *Construction and building materials*, 22(3), 364-369.
- Tsang, A. H. (2002). Strategic dimensions of maintenance management. *Journal of Quality in Maintenance Engineering*, 8(1), 7-39.
- Waziri, B. S. (2016). Design and construction defects influencing residential building maintenance in Nigeria. *Jordan Journal of Civil Engineering*, 10(3).

-
- World Health Organization. (2011). Early warning surveillance and response in emergencies: report of the second WHO technical workshop, 10-11 May 2011, World Health Organization, Geneva, Switzerland (No. WHO/HSE/GAR/DCE/2011.2). World Health Organization.
- Yousefli, Z., Nasiri, F., & Moselhi, O. (2017). Healthcare facilities maintenance management: a literature review. *Journal of Facilities Management*, 15(4), 352-375.
- Zhu, L., Shan, M., & Hwang, B. G. (2018). Overview of design for maintainability in building and construction research. *Journal of Performance of Constructed Facilities*, 32(1), 04017116.