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**Biometric Systems and Human Resource Operational Performance  
in Construction Material Manufacturing Companies within Nairobi  
Metropolitan Area, Kenya**



## **Biometric Systems and Human Resource Operational Performance in Construction Material Manufacturing Companies within Nairobi Metropolitan Area, Kenya**

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### **ABSTRACT**

**Purpose:** This study sought to assess the influence of biometric systems on the performance of construction material manufacturing companies within Nairobi, Machakos, Kiambu, and Kajiado counties. Specifically, the study sought to evaluate the effect of biometric system integration and analyze the impact of biometric data management systems on human resource operational performance. The study was guided by the Socio-Technical Systems Theory (STS) and Information Systems Success Model.

**Methodology:** A descriptive research design was adopted. The target population comprised management and supervisory staff with an estimated population of 1,621 individuals. The Krejcie and Morgan (1970) formula was used to determine representative sample size, and stratified random sampling was applied to ensure proportional representation across companies and managerial categories. Data was collected using a self-administered structured questionnaire. A pilot study, involving approximately 10% of the sample, was conducted to evaluate the clarity, validity, and reliability of the instrument. Collected data was coded, cleaned, and analyzed using SPSS version 25. Descriptive statistics including frequencies, percentages, means, and standard deviations—summarized the data, while inferential statistics such as multiple regression and correlation analysis were employed to examine the relationships among study variables at a 95% confidence level. The findings of the study were presented in tables and figures.

**Findings:** The study concludes that system integration have a significant effect on the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya. The study also concludes that data management systems have a significant effect on the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya.

**Unique Contribution to Theory, Policy and Practice:** Based on the findings, the study recommends that management of construction material manufacturing firms should invest in fully automated and integrated attendance systems, such as biometric fingerprint scanners and facial recognition time trackers.

**Keywords:** *Biometric Systems, System Integration, Data Management Systems, Human Resource Operational Performance, Construction Material, Manufacturing Companies*

## **Background of the Study**

The manufacturing sector remains a key pillar of global economic development, accounting for a significant proportion of GDP, job creation, and technological innovation (Manoj et al., 2021). Globally, manufacturing contributes approximately 16% of total GDP, underscoring its central role in advancing industrialization and improving living standards (Al-Shams et al., 2024). Over the last decade, the integration of advanced technologies including automation, digital systems, and data-driven management tools has notably enhanced production efficiency, capacity, and competitiveness (Sunarti et al., 2024). For example, global manufacturing output reached an estimated \$16 trillion in 2021, demonstrating the sector's immense significance.

Within this sector, the construction material industry including steel, cement, roofing, and related products has emerged as a foundational component for infrastructure development, urbanization, and economic progress. The World Steel Association reported that global crude steel production stood at 1.95 billion metric tons in 2021, highlighting a persistent demand driven by both public and private sector investments (Ali, Mustafa & Khan, 2022). In developing economies, construction material manufacturing is particularly vital, supporting major infrastructure projects and driving industrial expansion (Chuan-Chin et al., 2021; Yakubu et al., 2021).

In Africa, and Kenya specifically, the manufacturing and construction material industries are experiencing rapid transformation. The Nairobi Metropolitan Area which comprises Nairobi, Machakos, Kiambu, and Kajiado counties serves as the hub for many of the nation's leading construction material manufacturing companies. Firms such as Maisha Mabati Mills, National Cement Company Ltd, Bamburi Cement Ltd, East African Portland Cement Company, Mabati Rolling Mills Ltd, Savannah Cement Ltd, Royal Mabati Factory Ltd, Dada Paver Cabros Ltd, Devki Steel Mills Ltd, and Tononoka Steels Ltd contribute significantly to national economic output, industrialization, and employment (Kandie, 2023).

As the sector expands, human resource management (HRM) in these organizations faces growing complexity particularly in workforce attendance monitoring, workplace security, regulatory compliance, and data management. Traditional approaches to attendance tracking and access control have often been hampered by inefficiencies, errors, and security risks, including proxy attendance, unauthorized access, and data inaccuracy (Sunarti et al., 2024; Ubolo et al., 2024).

To address these challenges, construction material manufacturers in Nairobi Metropolitan Area are increasingly adopting biometric systems technologies that utilize unique physiological or behavioral characteristics, such as fingerprints and facial features, for employee identification and verification (Habibu, Talina & Elikana, 2022; Lonlwabo, 2023). Modern biometric attendance systems are deployed to eliminate time fraud and ensure accurate recording of employee work hours, while biometric access control systems are used to restrict facility entry to authorized personnel, thus enhancing site security.

Moreover, the integration of biometric systems with existing HRM, payroll, and enterprise resource planning (ERP) platforms allows organizations to streamline workflows, reduce administrative burden, and improve the reliability of HR processes (Sunarti et al., 2024). Biometric data management systems further ensure that sensitive employee information is securely stored, efficiently retrieved, and protected in compliance with Kenya's data protection regulations (Ubolo et al., 2024). These advancements collectively aim to improve organizational efficiency, employee accountability, and regulatory compliance in the manufacturing sector.

Despite the growing adoption of biometric technologies, there is limited empirical evidence evaluating their actual impact on HRM performance in the context of construction material manufacturing companies within the Nairobi Metropolitan Area. Challenges related to technology reliability, user acceptance, data security, and integration complexity may influence the effectiveness of these systems (Habibu, Talina & Elikana, 2022; Sunarti et al., 2024). There is, therefore, a need for comprehensive research to assess the practical outcomes and organizational value of biometric system implementation in this critical sector

The Nairobi Metropolitan Area, comprising Nairobi, Machakos, Kiambu, and Kajiado counties, stands as the industrial and economic nucleus of Kenya. This region plays a pivotal role in supporting the country's infrastructure development and urban expansion, with a high concentration of construction material manufacturing companies. These enterprises are responsible for producing and supplying essential materials such as cement, steel, roofing sheets, pavers, and related products that are vital to Kenya's construction and real estate sectors (Kenya Association of Manufacturers [KAM], 2023).

Construction material manufacturing in this region is characterized by the presence of both large-scale and medium-sized firms, many of which have established themselves as market leaders not only within Kenya but across East Africa. Companies such as Maisha Mabati Mills, National Cement Company, Bamburi Cement Limited, East African Portland Cement Company, Mabati Rolling Mills, and Devki Steel Mills have invested heavily in modern production facilities and advanced distribution networks. These organizations have contributed significantly to the national gross domestic product and serve as major sources of direct and indirect employment for thousands of Kenyans (Kandie, 2023).

The product portfolio within the sector is diverse, covering a wide range of construction essentials. Cement producers such as Bamburi Cement and National Cement Company cater to both local and export markets, ensuring a steady supply for public infrastructure and private projects alike. Meanwhile, companies specializing in roofing and steel products, including Mabati Rolling Mills, Maisha Mabati Mills, and Devki Steel Mills, meet the demand for materials required in residential, commercial, and industrial construction. Many of these companies have expanded their capacity over the years, embracing technological innovation and

automation to enhance production efficiency, maintain international quality standards, and respond to the dynamic needs of the construction market (KAM, 2023).

Human resource management within these companies is multifaceted, involving the coordination of a large and diverse workforce operating in multiple shifts and often under strict safety protocols. Ensuring workforce discipline, accurate attendance tracking, secure access control, and efficient payroll management is essential for operational success. As such, there has been a clear shift towards digital transformation, with many firms in the Nairobi Metropolitan Area adopting advanced HRM systems, including biometric solutions, to streamline operations and improve human resource operational performance (Kuria & Gichoya, 2022).

Despite remarkable growth and modernization, the sector continues to grapple with challenges such as fluctuating costs of raw materials, competition from imported products, infrastructure limitations, and the need to comply with stringent regulatory standards on safety and environmental management. The disruption caused by the COVID-19 pandemic further accelerated the adoption of digital and contactless technologies, such as biometric systems, highlighting the industry's commitment to innovation, efficiency, and resilience (World Bank, 2022). Through continuous improvement and the embrace of advanced technology, construction material manufacturing companies in the Nairobi Metropolitan Area are poised to remain at the forefront of Kenya's industrial and economic transformation.

### **Statement of the Problem**

The construction material manufacturing sector is a big contributor to Kenya's economic growth, accounting for a substantial share of GDP, employment, and infrastructure development (KNBS, 2022). According to the Kenya National Bureau of Statistics, manufacturing contributed 8.4% to Kenya's GDP in 2020, with the construction materials sub-sector comprising cement, steel, roofing, and allied products playing a central role in supporting the country's expanding urbanization and infrastructure investments (KAM, 2022). The sector directly and indirectly supports over 300,000 jobs and underpins the competitiveness of regional exports. Yet, manufacturers operating within the Nairobi Metropolitan Area continue to grapple with operational inefficiencies, rising labor costs, time management challenges, and security threats, all of which undermine productivity and human resource operational performance (Kandie, 2023).

To address these persistent challenges, a growing number of firms in the region have invested in advanced digital solutions, particularly biometric systems. Biometric technologies including fingerprint and facial recognition are increasingly adopted to automate attendance tracking, secure access to production facilities, and integrate with payroll and HR management systems (Sunarti et al., 2024; Ubolo et al., 2024). Globally, studies indicate that biometric systems can reduce time theft, enhance employee accountability, and streamline administrative processes (Ali, Mustafa & Khan, 2022). Locally, preliminary evidence suggests that manufacturers

deploying biometric attendance systems have observed up to a 30% reduction in absenteeism and payroll discrepancies (Kuria & Gichoya, 2022). Kamau (2021) also found that integrated security systems, including biometrics, led to a 40% reduction in security breaches within manufacturing plants in Nairobi.

Despite these promising indicators, the effectiveness of biometric systems in improving human resource operational performance in the Nairobi Metropolitan Area remains insufficiently understood. Several companies still report ongoing issues related to unreliable system integration, incomplete data capture, user resistance, and significant costs for acquisition and maintenance (Karanja & Mwangi, 2019; Ubolo et al., 2024). Data privacy concerns and compliance with the Data Protection Act further complicates the landscape, particularly as the volume of sensitive employee information grows.

The risks of inadequate HR and payroll management have also become evident through high-profile cases in the sector. For instance, the closure and administration of Savannah Cement in 2023 was widely attributed not only to financial distress and shareholder disputes but also to alleged HR operational failures including reports of ghost workers and inflated payrolls which resulted in substantial financial losses and a decline in organizational credibility (Business Daily Africa, 2023; Nation Africa, 2024). This case illustrates how weaknesses in attendance tracking, access control, and data management can have far-reaching consequences for organizational performance and sustainability.

Moreover, the impact of biometric attendance systems, access control solutions, seamless integration with HR and payroll functions, and secure biometric data management on core performance metrics such as time discipline, productivity, payroll accuracy, and security has yet to be rigorously evaluated in this context. Without a comprehensive, data-driven assessment, companies risk underutilizing these technologies, missing opportunities for efficiency gains, or exposing themselves to new vulnerabilities.

This study therefore sought to bridge this knowledge gap by critically examining biometric systems and human resource operational performance in construction material manufacturing companies within Nairobi Metropolitan Area, Kenya. The research aimed to generate empirical insights that guide technology adoption, optimize HRM practices, and inform industry stakeholders and policymakers for improved organizational effectiveness in Kenya's manufacturing sector.

## **Objectives of the Study**

### **General Objective**

The general objective of this study is to assess the biometric systems and human resource operational performance in construction material manufacturing companies within Nairobi Metropolitan Area, Kenya.

### **Specific Objectives**

- i. To assess the influence of system integration on the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya.
- ii. To analyse the influence of biometric data management systems on the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya.

### **Theoretical Review**

A theory is a group of concepts and ideas used in the explanation of events and other things, particularly the ones based on general principles independent of the event to be explained. The theoretical review gives an introduction of the theories that are used to express the reason for the existence of the research. In addition, a theoretical review provides the main variables that affect the phenomenon under study and points out the need to consider the effect of these variables under different circumstances (Sahal & Bett, 2022). This study was guided by Socio-Technical Systems Theory (STS) and Information Systems Success Model.

### **Socio-Technical Systems Theory (STS)**

Socio-Technical Systems Theory (STS) is a foundational framework that emphasizes the interdependent relationship between people (the social system) and technology (the technical system) within an organizational context. First introduced by Trist and Bamforth (1951), the theory has evolved to become a key lens through which modern organizations assess the success of technology integration (Mukherjee & Davis, 2021). STS posits that for any technological innovation to be effective, there must be alignment between technical processes (hardware, software, systems) and the human components (users, culture, workflows) that interact with them. Neither system can function optimally in isolation; both must be designed and managed jointly to enhance human resource operational performance (Munyua & Karanja, 2023).

Socio-Technical Systems Theory is especially useful for understanding how the merging of biometric technologies (e.g., fingerprint or facial recognition systems) with existing human resources, payroll, or access control systems affects overall performance. Successful integration is not only a technical challenge but also a social and organizational one, requiring user training, workflow adjustments, and policy alignment (Kipchumba & Owino, 2022).

Recent studies show that failure to consider the social context such as employee attitudes, departmental coordination, and leadership support often results in low utilization, resistance to change, and eventual system underperformance, regardless of the technological capability (Nduati & Wambua, 2024). Conversely, when technology is implemented alongside efforts to align it with organizational culture and employee expectations, performance outcomes such as

process efficiency, accountability, and data accuracy are significantly enhanced (Wekesa & Mwangi, 2021).

Socio-Technical Systems theory also reinforces the importance of feedback loops, continuous evaluation and adaptation of systems based on user experience and organizational dynamics. This is crucial in ensuring that biometric systems remain responsive to changing performance demands and are not rendered obsolete by technological or procedural shifts (Achieng & Kamau, 2023). By recognizing that technology alone is insufficient without social adaptation, Socio-Technical Systems theory provided a robust framework to assess the effect of biometric system integration on the performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya.

### **Information Systems Success Model**

The Information Systems (IS) Success Model, originally developed by DeLone and McLean (1992) and later updated in 2003, provides a comprehensive framework for assessing the effectiveness of information systems within organizations. The model identifies six key interrelated dimensions of system success: system quality, information quality, service quality, use, user satisfaction, and net benefits (DeLone & McLean, 2003).

This model is particularly relevant for evaluating how effectively data is captured, stored, processed, and utilized to enhance human resource operational performance. System quality refers to the functionality, reliability, and responsiveness of the biometric platforms; information quality assesses the accuracy, timeliness, and completeness of biometric records; and service quality evaluates the technical support and system responsiveness experienced by users (Abdullahi & Balozzi, 2021). These quality dimensions influence both actual system use and user satisfaction, two critical factors that determine whether the biometric data management system is perceived as successful. In modern organizational settings, where real-time attendance logs and access records feed into HR analytics and payroll systems, the quality of biometric data directly impacts operational efficiency and decision-making accuracy (Otieno & Kavulavu, 2023).

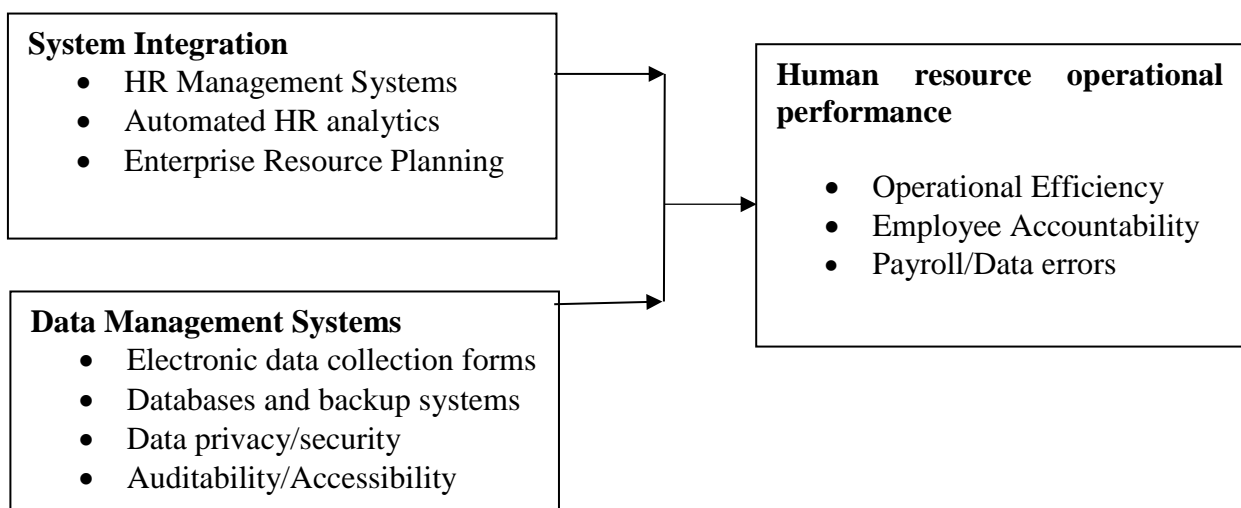
Importantly, the IS Success Model emphasizes net benefits, which represent the overall impact of the system on individual and human resource operational performance. For biometric data management systems, these may include reduced payroll errors, improved workforce monitoring, better compliance reporting, and stronger data security (Mwangi & Musyoka, 2022). If the system facilitates better decisions, enhances accountability, and contributes to measurable improvements in performance, it is considered successful under this model.

Recent adaptations of the IS Success Model stress the need to incorporate factors such as data governance, user training, and change management when assessing biometric systems in large organizations (Omondi & Limo, 2024). These considerations ensure that biometric data systems not only function technically but also provide strategic value to the business. Thus, the Information Systems Success Model provided a robust theoretical foundation to analyse the

influence of biometric data management systems on the performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya.

### Conceptual Framework

A conceptual framework is a structured representation or model that outlines the key variables or concepts within a study and shows the relationships between them (Mugenda & Mugenda, 2019). It serves as a guide to help researchers understand the theoretical foundations of their study and how different factors might influence or interact with each other (Cooper & Schindler, 2019).



**Independent Variables**

**Dependent Variable**

**Figure 1: Conceptual Framework**

#### System Integration

System integration is the process of embedding biometric technologies, such as fingerprint readers, facial recognition systems, or iris scanners into an organization's broader digital infrastructure. This infrastructure typically includes Human Resource Management Systems (HRMS), payroll platforms, Enterprise Resource Planning (ERP) systems, and security and compliance monitoring tools. Integration enables seamless data flow between biometric input devices and internal administrative systems, supporting real-time workforce management, operational transparency, and automated decision-making (Mukherjee & Davis, 2021).

In contemporary organizations, especially those with large and dispersed workforces, standalone biometric systems are often inadequate. Without integration, biometric data remains isolated, limiting its usability. Integrated systems, on the other hand, allow biometric data such as clock-in/clock-out times, access logs, and verification attempts to be automatically shared across

multiple departments reducing redundancy, increasing speed, and ensuring accuracy (Munyua & Karanja, 2023).

Real-time synchronization refers to the ability of the system to instantly update biometric records across all linked platforms the moment an activity occurs—such as employee check-in, access authorization, or exit logging. This is crucial in dynamic work environments where immediate access to up-to-date information supports shift planning, incident response, and payroll adjustments. Failure to achieve real-time synchronization can result in data lags, where different departments work with outdated or conflicting information—leading to delayed decisions, miscommunication, and errors in reporting. When implemented successfully, real-time synchronization supports timely HR and operational interventions, improves resource allocation, and enhances decision-making efficiency (Kipchumba & Owino, 2022).

System interoperability is the extent to which the biometric system can communicate and exchange data with existing enterprise systems, regardless of differences in platform, software architecture, or vendor. In large organizations with multiple departments and branches, systems from different vendors must operate together seamlessly. For example, biometric data should flow from attendance devices to payroll software, HR dashboards, and compliance logs without requiring manual transfers. High interoperability reduces the need for duplicated data entry, minimizes integration costs, and enables centralized control over decentralized operations. Conversely, low interoperability leads to data fragmentation, inefficiencies, and increased IT maintenance demands. It also increases the risk of manual errors, which can compromise the reliability of attendance, salary processing, and performance evaluation (Nduati & Wambua, 2024).

Data consistency ensures that biometric data remains accurate, complete, and synchronized across all systems and departments. This means that an employee's attendance recorded by the biometric device should match the data displayed in HR reports, payroll summaries, and system audits—without variations or omissions. Inconsistent data creates multiple problems: payroll discrepancies, employee complaints, inaccurate KPIs, and even audit non-compliance. For organizations operating at scale, where thousands of biometric entries are logged daily, maintaining consistency is not only a technical necessity but also a governance requirement. Strong data consistency fosters employee trust, ensures regulatory compliance, and supports reliable performance evaluation (Ochieng & Kamau, 2023).

When biometric systems are properly integrated, they significantly improve human resource operational performance by streamlining processes, enhancing data accuracy, and reducing operational costs. Integration ensures that key departments such as HR, Finance, and Security operate on a single source of truth, which improves collaboration and accountability. Moreover, integration reduces manual workload, minimizes payroll errors, and enables proactive workforce management through real-time data analytics. In large organizations, integration is also essential

for scaling operations without compromising control, efficiency, or compliance. It turns biometric systems from isolated access tools into strategic enablers of performance, governance, and digital transformation.

### **Data Management Systems**

Data Management Systems refer to the infrastructure, tools, and protocols used to store, process, secure, and retrieve biometric data, such as fingerprints, facial templates, iris scans, and voice prints, within an organization. These systems are critical for transforming raw biometric inputs into actionable, compliant, and verifiable records used across departments for attendance monitoring, access control, payroll, compliance auditing, and decision-making (Abdullahi & Balazi, 2021).

Unlike traditional data systems, biometric data management requires heightened security, integrity, and scalability, given the sensitive and non-replicable nature of biometric identifiers. Mismanagement of biometric data can lead to identity fraud, payroll disputes, and regulatory violations. Therefore, organizations must invest in systems that ensure not only data availability but also data accuracy, traceability, and protection (Otieno & Kavulavu, 2023).

Data accuracy refers to the correct capture and representation of biometric characteristics in the system. Biometric data must be captured clearly (e.g., well-scanned fingerprints or properly framed facial images) and processed into templates without distortion or corruption. Accurate data ensures that the right individuals are verified, and that attendance, access, and payroll records are based on reliable inputs. Inaccurate data may result in failed verifications (false rejections), wrongful denials of access, or misrepresentation in HR systems. Data accuracy is especially vital in organizations that operate on real-time biometric verification across multiple departments or branches (Chomba & Wambugu, 2023).

Data security refers to the mechanisms in place to protect stored biometric templates from unauthorized access, breaches, or tampering. Since biometric data is permanent and uniquely tied to individuals, its compromise can have long-term consequences unlike passwords or access tokens that can be reset (Mwangi & Musyoka, 2022). Key security measures include encryption, role-based access control, audit trails, and compliance with data protection regulations like Kenya's Data Protection Act (2019). Weak security exposes the organization to risks including identity theft, reputational damage, and legal penalties. A secure biometric data environment is essential for maintaining employee trust and ensuring ethical technology use (Omondi & Limo, 2024).

Data accessibility and auditability assesses how well the system allows authorized personnel to access, retrieve, and audit biometric records when needed. Timely and controlled access is necessary for resolving disputes (e.g., absenteeism or access denial), conducting compliance reviews, and evaluating performance trends. Auditability also involves maintaining detailed logs of system interactions—who accessed what data, when, and for what purpose. Systems lacking

audit trails limit an organization's ability to trace incidents and ensure accountability. Therefore, structured access protocols and transparent data trails are essential for governance and performance evaluation (Achieng & Kamau, 2023).

Data management systems directly impact human resource operational performance by enabling accurate employee records, timely payroll processing, secure access control, and informed decision-making. When managed effectively, biometric data becomes a strategic asset that enhances operational efficiency, regulatory compliance, and digital resilience. In large organizations, poor data management leads to inconsistencies, payroll disputes, and auditing failures, all of which undermine performance. Conversely, well-managed biometric data systems contribute to accountability, trust, and sustainable workforce management.

## **Empirical Review**

### **System Integration and Human Resource Operational Performance**

In today's data-driven organizations, the integration of biometric systems with core platforms such as HR, payroll, and ERP has become a key driver of administrative efficiency and process automation. Mukherjee and Davis (2021) explored this relationship in a study conducted across several Indian multinational firms. The findings showed that organizations that synchronized biometric time log directly with payroll systems significantly reduced processing time, payroll disputes, and data entry errors. The researchers highlighted that system integration not only increased transparency but also enhanced the speed of decision-making in HR departments.

A study by Munyua and Karanja (2023) in Kenyan manufacturing firms revealed that seamless integration between biometric access systems and internal security dashboards helped streamline access control and incident reporting. Rather than managing data across multiple platforms, integrated systems enabled centralized control, thereby reducing internal risks and enhancing coordination between departments. The study emphasized that system integration positively influences performance by unifying fragmented workflows.

In a comparative assessment of integrated versus standalone biometric systems, Kipchumba and Owino (2022) found that companies using integrated systems reported higher levels of operational efficiency. These firms were able to automate reporting, improve attendance analysis, and enhance real-time staff monitoring. Integration also allowed for cross-validation of data, which improved audit compliance and payroll accuracy. The authors concluded that integrated biometric solutions offer greater ROI by reducing manual workload and supporting strategic planning.

Furthermore, Nduati and Wambua (2024) examined the long-term sustainability of biometric deployments in the Kenyan public sector. They found that while standalone systems initially improved attendance, only integrated systems sustained performance improvements over time. Integration with payroll and performance appraisal platforms allowed biometric data to inform a

broader workforce analytics, improving decision-making at the executive level. The study recommended that system integration be treated as a strategic initiative, not just a technical upgrade.

According to Wekesa and Mwangi (2021), successful integration of biometric systems also hinges on interoperability. Their research across regional hospitals and universities showed that institutions with interoperable biometric-HR systems experienced smoother onboarding of staff, faster leave processing, and reduced HR bottlenecks. As a result, these institutions were better able to align workforce management with institutional goals ultimately enhancing service delivery and internal efficiency.

### **Data Management Systems and Human Resource Operational Performance**

Effective handling of biometric data capturing, storing, processing, and retrieving is fundamental to the reliability and sustainability of any biometric system. In a study focused on public and private sector institutions in Kenya, Otieno and Kavulavu (2023) reported that organizations with centralized and well-structured biometric data management platforms experienced fewer system inconsistencies, faster resolution of attendance disputes, and more accurate payroll processing. The researchers emphasized that robust data management reinforces operational transparency and employee trust.

Instead of focusing solely on system deployment, some studies have investigated the quality of the data lifecycle. For example, Chomba and Wambugu (2023) explored how data accuracy and consistency within biometric platforms affected payroll efficiency across multiple manufacturing firms. The results revealed that even minor inconsistencies in biometric data such as mismatched timestamps or duplicate entries resulted in payroll errors, delays in approvals, and internal friction. The authors concluded that strong data validation mechanisms are critical to realizing the performance benefits of biometric systems.

Security remains a major concern in the management of biometric information. In a cross-industry analysis conducted by Mwangi and Musyoka (2022), the researchers found that data breaches and unauthorized access incidents were more common in institutions lacking encryption, access controls, and audit trails in their biometric systems. Organizations with stronger biometric data security frameworks not only avoided compliance violations but also demonstrated higher employee confidence in the use of such systems—ultimately contributing to a safer and more performance-aligned workplace.

Auditability and accessibility are also emerging as performance-critical factors. Achieng and Kamau (2023) highlighted this in their study of biometric systems in government offices. They found that institutions that maintained detailed access logs and audit trails for biometric data could resolve internal queries and disputes more efficiently. In contrast, systems with limited traceability often led to prolonged investigations, employee dissatisfaction, and gaps in

accountability. The study concluded that the ability to audit and access biometric data on demand plays a key role in organizational responsiveness and governance.

Looking at biometric data management from a systems design perspective, Omondi and Limo (2024) examined the scalability and integration of biometric data warehouses in large educational institutions. Their findings showed that scalable storage systems with structured retrieval protocols significantly enhanced the utility of biometric data in long-term decision-making—such as tracking attendance trends, identifying absenteeism patterns, and informing staffing policies. The study noted that performance outcomes improve when biometric data systems are designed with future-proof capacity, consistency, and accessibility in mind.

## **RESEARCH METHODOLOGY**

### **Research Design**

The descriptive research design was employed where data was collected one point in time. Creswell and Creswell (2019) notes that a descriptive survey seeks to obtain information that describes existing phenomena by asking questions relating to individual perceptions and attitudes. The design is considered suitable as it allows an in-depth study of the problem under investigation. Descriptive research design was adopted when describing the given situation, a phenomenon, it takes into consideration current customs and also traditions in data collection (Baumgartner, Strong & Hensley 2019).

### **Target Population**

According to Creswell (2019), a population refers to a well-defined set of individuals, services, elements, events, or groups that are the focus of a particular investigation. Egbert (2019) further defines population as the complete set of units from which information is drawn to enable generalization of research findings. The target population, therefore, encompasses those units for which the conclusions of the study are intended to apply.

This study was conducted among selected construction material manufacturing companies within Nairobi Metropolitan Area, Kenya. The Nairobi Metropolitan Area covers Nairobi, Machakos, Kiambu, and Kajiado counties, which collectively host a concentration of leading companies in the construction material manufacturing sector. The specific companies in this study included Maisha Mabati Mills Ltd, National Cement Company Ltd, Bamburi Cement Limited, East African Portland Cement Company, Mabati Rolling Mills Ltd, Abyssinia Iron & Steel Ltd, Royal Mabati Factory Ltd, Dada Paver Cabros Ltd, Devki Steel Mills Ltd, and Tononoka Steels Ltd. These firms represent a cross-section of industry, encompassing manufacturers of cement, steel, roofing sheets, pavers, and related products.

The total workforce across these companies is substantial, comprising thousands of employees from top management to general staff. This significant employee base is part of the key reason these companies were selected as the target population for the study. However, this study

primarily focused on management and supervisory staff such as human resource managers, ICT personnel, plant managers, and security supervisors as they are directly involved in the planning, implementation, and oversight of biometric systems. The target population for this study comprised the 1621 management and supervisory employees from the selected construction material manufacturing companies. These individuals are deemed best positioned to provide informed perspectives on the influence of biometric attendance systems, access control, system integration, and biometric data management on human resource operational performance within the construction material manufacturing sector in Nairobi Metropolitan Area.

**Table 1: Target Population**

Category	Target Population
Top level Managers	270
Middle Level managers	540
Lower-Level Managers	811
<b>Total</b>	<b>1621</b>

### Sample Size and Sampling Technique

Sampling is the process of selecting a representative portion of a target population for the purpose of obtaining information that can be generalized to the entire population. According to Mugenda and Mugenda (2019), a sample should be carefully selected to ensure that it adequately reflects the characteristics of the population from which it is drawn. The study used Krejcie and Morgan (1970) formula to arrive at the sample size. The selection formula was as follows:

$$n = \frac{N}{1 + (N-1)e^2}$$

Where n= the required sample size

N = is the Target Population (246)

e = accuracy level required. Standard error = 5%

Sample calculation

$$n = \frac{1621}{1 + (1621)0.05^2}$$

n=321

n=321 respondents

The sample study size was 321 management employees. Stratified random sampling was applied to get the respondents. The study then used simple random sampling to select respondents from each stratum. In simple random sampling, every respondent has an equal chance of participating in the study.

**Table 2: Sample Size**

<b>Category</b>	<b>Target Population</b>	<b>Sample Size</b>
Top level Managers	270	53
Middle Level managers	540	107
Lower-Level Managers	811	161
<b>Total</b>	<b>1621</b>	<b>321</b>

### **Data Collection Instrument**

Data was collected using a self-administered structured questionnaire. Structured questionnaires were used since they enabled the researcher to collect quantitative data. Questionnaires are a good method because they provide clarifications seek by respondents and they can be collected immediately after they are completed. Structured questionnaires are easy to administer, analyze and are economical in terms of time and money. A five-point Likert scale was used to measure all variables. The lowest rating of 1 signifies a low opinion by respondent while a high rating of 5 signifies a high rating by the respondents.

### **Pilot Study**

A pilot test was conducted to determine validity and reliability of the data collection instrument. A pilot study is a small experiment designed to test logistics and gather information prior regarding a larger study, in order to improve the latter quality and efficiency. A pilot study can reveal deficiencies in the design of proposed experiment and procedure and these can be addressed before time and resources are expended on large scale studies. The responses from respondents were used to adjust and refine questionnaire accordingly. According to Mugenda and Mugenda (2019) the pretest sample should be between 1% and 10% depending on the sample size. In this study, the pilot study comprised of 32 respondents which was 10% of the sample size.

### **Data Analysis and Presentation**

Data obtained from the field was coded, cleaned, and entered into the computer for analysis using SPSS version 25. The data was summarized in order to see emerging trends and issues around specific themes, which are dependent on the variables and objectives. The presentation of data was done in the form of quantitative and qualitative reports which were presented in forms of tables and essay. For the quantitative reports, the tables consisted of mean and standard deviation values that were used to make interpretation of the analysis. Percentage, mean and standard deviation were used to show the frequency of responses. Tables were used to display the rate of responses and to facilitate comparison.

Descriptive statistical included frequency, percentages, mean and standard deviation. Inferential statistical analysis used was multiple regression and correlation analysis. The significance of each independent variable was tested at a confidence level of 95%. The multiple regression model was as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$$

Where;

Y = dependent variable (performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya).

X<sub>1</sub> = System Integration

X<sub>2</sub> = Data Management Systems

β<sub>0</sub> = the constant term

β<sub>1-2</sub> = the Beta coefficient

ε = the error term

## DISCUSSION OF FINDINGS AND RESULTS

### Descriptive statistics

#### System Integration and the Human Resource Operational Performance

The first specific objective of the study was to assess the influence of system integration on the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya. The respondents were requested to indicate their level of agreement on various statements relating to system integration and the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya. A 5-point Likert scale was used where 1 symbolized strongly disagree, 2 symbolized disagree, 3 symbolized neutral, 4 symbolized agree and 5 symbolized strongly agree. The results were as presented in Table 3.

From the results, the respondents agreed that the biometric system integrates well with payroll and HR systems. This is supported by a mean of 3.943 (std. dv = 0.986). In addition, as shown by a mean of 3.926 (std. dv = 0.840), the respondents agreed that data sharing between the biometric and other enterprise systems is seamless. Further, the respondents agreed that Integration has reduced workload for administrative staff. This is shown by a mean of 3.846 (std. dv = 0.879). The respondents also agreed that Biometric integration has improved real-time decision making. This is shown by a mean of 3.831 (std. dv = 0.904). As shown by a mean of 3.816 (std. dv = 0.789), the respondents agreed that Technical support for integrated systems is adequate.

**Table 3: System Integration and the Human Resource Operational Performance**

	<b>Mean</b>	<b>Std. Deviation</b>
The biometric system integrates well with payroll and HR systems.	3.943	0.986
Data sharing between the biometric and other enterprise systems is seamless.	3.926	0.840
Integration has reduced workload for administrative staff.	3.846	0.879
Biometric integration has improved real-time decision making.	3.831	0.904
Technical support for integrated systems is adequate.	3.816	0.789
<b>Aggregate</b>	<b>3.788</b>	<b>0.897</b>

### **Biometric Data Management Systems and the Human Resource Operational Performance**

The second specific objective of the study was to analyse the influence of biometric data management systems on the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya. The respondents were requested to indicate their level of agreement on various statements relating to biometric data management systems and the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya. A 5-point Likert scale was used where 1 symbolized strongly disagree, 2 symbolized disagree, 3 symbolized neutral, 4 symbolized agree and 5 symbolized strongly agree. The results were as presented in Table 4.

From the results, the respondents agreed that biometric data is handled securely and confidentially. This is supported by a mean of 3.891 (std. dv = 0.865). In addition, as shown by a mean of 3.818 (std. dv = 0.945), the respondents agreed that data retrieval from the biometric system is efficient. Further, the respondents agreed that company complies with data protection regulations for biometric data. This is shown by a mean of 3.808 (std. dv = 0.611). The respondents also agreed that staff are informed about how their biometric data is used and stored. This is shown by a mean of 3.721 (std. dv = 0.908). As shown by a mean of 3.661 (std. dv = 0.776), the respondents agreed that there are regular audits on biometric data management practices.

**Table 4: Biometric Data Management Systems and the HR Operational Performance**

	<b>Mean</b>	<b>Std. Deviation</b>
Biometric data is handled securely and confidentially.	3.891	0.865
Data retrieval from the biometric system is efficient.	3.818	0.945
Company complies with data protection regulations for biometric data.	3.808	0.611
Staff are informed about how their biometric data is used and stored.	3.721	0.908
There are regular audits on biometric data management practices.	3.661	0.776
<b>Aggregate</b>	<b>3.765</b>	<b>0.758</b>

### **Inferential Statistics**

Inferential statistics in the current study focused on correlation and regression analysis. Correlation analysis was used to determine the strength of the relationship while regression analysis was used to determine the relationship between dependent variable (human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya) and independent variables (system integration and biometric data management systems).

### **Correlation Analysis**

The present study used Pearson correlation analysis to determine the strength of association between independent variables (system integration and biometric data management systems) and the dependent variable (human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya). Pearson correlation coefficient range between zero and one, where by the strength of association increase with increase in the value of the correlation coefficients.

**Table 5: Correlation Coefficients**

		HR Performance	Operational	System Integration	Biometric Management Systems	Data
HR Performance	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	298				
System Integration	Pearson Correlation	.826**	1			
	Sig. (2-tailed)	.002				
	N	298	298			
Biometric Management Systems	Pearson Correlation	.871**	.278	1		
	Sig. (2-tailed)	.000	.076			
	N	298	298	298		

From the results, there is a very strong relationship between system integration and the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya ( $r = 0.826$ ,  $p$  value = 0.002). The relationship was significant since the  $p$  value 0.002 was less than 0.05 (significant level). The findings are in line with the findings of Munyua and Karanja (2023) that there is a very strong relationship between system integration and organization performance.

The results also revealed that there was a very strong relationship between biometric data management systems and the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya ( $r = 0.871$ ,  $p$  value = 0.000). The relationship was significant since the  $p$  value 0.000 was less than 0.05 (significant level). The findings are in line with the results of Otieno and Kavulavu (2023) who revealed that there is a very strong relationship between biometric data management systems and organization performance.

### Regression Analysis

Multivariate regression analysis was used to assess the relationship between independent variables (system integration and biometric data management systems) and the dependent variable (human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya)

**Table 6: Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.931	.857	.858	.10428

a. Predictors: (Constant), system integration and biometric data management systems

The model summary was used to explain the variation in the dependent variable that could be explained by the independent variables. The R-squared for the relationship between the independent variables and the dependent variable was 0.857. This implied that 85.7% of the variation in the dependent variable (human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya) could be explained by independent variables (system integration and biometric data management systems).

**Table 7: Analysis of Variance**

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	141.081	2	70.541	2867.52	.000 <sup>b</sup>
1 Residual	7.254	295	.0246		
Total	148.335	297			

a. Dependent Variable: the human resource operational performance

b. Predictors: (Constant), system integration and biometric data management systems

The ANOVA was used to determine whether the model was a good fit for the data. F calculated was 2867.52 while the F critical was 3.026. The p value was 0.000. Since the F-calculated was greater than the F-critical and the p value 0.000 was less than 0.05, the model was considered as a good fit for the data. Therefore, the model can be used to predict the influence of system integration and biometric data management systems on human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya.

**Table 8: Regression Coefficients**

Model		Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.
		B	Std. Error			
1	(Constant)	0.239	0.061		3.918	0.000
	System integration	0.357	0.098	0.356	3.643	0.002
	Biometric data management systems	0.375	0.099	0.376	3.788	0.001

a Dependent Variable: human resource operational performance

The regression model was as follows:

$$Y = 0.239 + 0.357X_3 + 0.375X_4$$

According to the results, system integration has significant effect on the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya,  $\beta_1=0.357$ ,  $p$  value= 0.002). The relationship was considered significant since the  $p$  value 0.002 was less than the significant level of 0.05. The findings are in line with the findings of Munyua and Karanja (2023) that there is a very strong relationship between system integration and organization performance.

In addition, the results revealed that biometric data management systems has significant effect on the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya,  $\beta_1=0.375$ ,  $p$  value= 0.001). The relationship was considered significant since the  $p$  value 0.001 was less than the significant level of 0.05. The findings are in line with the results of Otieno and Kavulavu (2023) who revealed that there is a very strong relationship between biometric data management systems and organization performance.

## CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

The study concludes that system integration have a significant effect on the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya. The study findings revealed that HR management Systems (HRIS), automated HR analytics and enterprise Resource Planning (ERPs) influences operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya.

The study also concludes that data management systems have a significant effect on the human resource operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya. The study findings revealed that electronic data collection forms, databases and backup systems, data privacy/security and auditability/Accessibility influences operational performance of construction material manufacturing companies within Nairobi Metropolitan Area, Kenya.

### Recommendations

In light of the significant influence of system integration on human resource operational performance, the study recommends that management should integrate HR Management Information Systems (HRIS) with Enterprise Resource Planning (ERP) platforms. Such integration will enable seamless data flow across departments, improve decision-making through automated HR analytics, and enhance efficiency in workforce planning, payroll management, and performance monitoring.

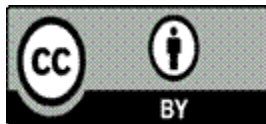
Considering the significant effect of data management systems on human resource operational performance, the study recommends that management should strengthen digital data management frameworks by adopting secure databases, regular data backup systems, and strict data privacy and security protocols. This will ensure data integrity, enhance accessibility for authorized users, and support compliance with regulatory requirements while improving the reliability of HR records.

## REFERENCES

- Ali, A, Mustafa, J & Khan, I. U. (2022). Relationship of Biometric Attendance System with Performance, Job Related Stress and Satisfaction of University Teachers. *Liberal Arts and Social Sciences International Journal*, 2(2), 42-49.
- Bryman, A. (2019). *Social Research Methods* (5th ed.). Oxford University Press.
- Christ, A, Wenzel, V, Faath, A & Anderl, R. (2020). Integration of Feature Templates Storage Module in Product Structures Improves Knowledge Reuse San Francisco, USA. *Proceedings of the World Congress on Engineering and Computer Science*, 2(1), 1-9
- Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education* (8th ed.). Routledge.
- Ferguson, K. M & Heidemann, G. (2020). Organizational strengths and challenges of Kenyan NGOs serving orphans and vulnerable children: a template storage module analysis. *International Journal of Social Welfare*, 18(1), 354-364
- Flick, U. (2019). *An Introduction to Qualitative Research* (6th ed.). SAGE Publications.
- Glaser, B. G., & Strauss, A. L. (2019). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Aldine.
- Grant, R. (2019). *Contemporary Strategy Analysis*, (4 Ed). Blackwell Publishers
- Guba, E. G., & Lincoln, Y. S. (2020). "Competing Paradigms in Qualitative Research." In Denzin, N. K., & Lincoln, Y. S. (Eds.), *Handbook of Qualitative Research* (pp. 105-117). SAGE Publications.
- Han-Foon, N, Devinaga, R, Tong, D. Y. K & Chuan-Chin, T. (2021). Biometric technology and privacy: a perspective from tourist satisfaction. *Information Technology Tourism*, 14(5), 219–237.
- Jaafa, N. K, Mokaya, B, Savai, S. M, Yeung, A, Siika, A. M & Were, M. (2021). Implementation of Fingerprint biometric systems for Unique Patient Matching and Identification at an HIV Care and Treatment Facility in Western Kenya: Cross-sectional Study. *Journal of Medical Internet Research*, 23(12), 21-36.

- Kothari, C. R. (2019). Research methodology: Methods and techniques. New Age International
- Lonlwabo, V. S. (2023). *Biometric technology adoption as a technique for tracking employee attendance at government-run schools in the Eastern Cape*. Retrieved from <https://d1wqtxts1xzle7.cloudfront.net/111211717/>
- Mandari, H & Koloseni, D. (2021). Biometric Authentication in Financial Institutions: The intention of Banks to Adopt Biometric Powered ATM. *Advances in Computer Science: an International Journal*, 5(4), 9-18.
- Miao, P. Z. Q, Song, J, Yutao, Q, Liu, R & Daohui, G. (2020). Architectural Style Classification Based on Feature Extraction Module. *Digital Object Identifier*, 6(1), 52598-52606
- Mugambi, G, Rimiru, R, Kimwele, M, Muriuki, C. (2024). *Multi-Temporal Feature Extraction Module Fusion for Spatial-Temporal Dependencies Enhanced Change Detection in Kenya*. Retrieved from <https://dl.acm.org/doi/pdf/>
- Mugenda, O. M., & Mugenda, A. G. (2019). *Research methods: Quantitative and qualitative approaches*. African Centre for Technology Studies.
- Mukoya, E, Rimiru, R & Kimwele, M. (2023). *Enhanced fingerprint pattern classification: Integrating attention feature extraction modules with lightweight deep learning models*. Retrieved from <https://onlinelibrary.wiley.com/doi/>
- Muriuki, J. W, Cheruiyot, T & Komen, J. (2020). Influence of decision-making module on Organizational Performance of State Corporations in Kenya. *Science Journal of Business and Management*, 5(4), 136-148.
- Mwangi K, Mwangi, M, Wahuga, D, Sang'alo, S, Kenyatta, E & Misango, S. (2022). Biometric system validation on organization performance: a case of South Eastern Kenya University. *International Journal of Recent Research in Mathematics Computer Science and Information Technology*, 9(2), 92-99.
- Mwema, J, Kimwele, M & Kimani, S. (2020). A Simple Review of Biometric Template Storage Module Protection Schemes Used in Preventing Adversary Attacks on Biometric Fingerprint Templates in Kenya. *International Journal of Computer Trends and Technology*, 20(1), 12-18
- Njoroge, A, Dunbarc, M. D, Abunab, F, Simpsond, P, Machariaf, P, Betza, B, Cherutiche, P, Bukusig, D & Carey, F. (2021). *Feasibility and acceptability of an iris biometric system for unique patient identification in routine HIV services in Kenya*. Retrieved from <https://pmc.ncbi.nlm.nih.gov/articles/PMC6939164/>
- Ohulo, L. A. (2020). *Evaluation of Data Capture Module Methods used in Plant Health Clinics in Kenya*. Retrieved from <https://repository.ruforum.org/system/>

- Omotosho, F. S, Babatunde, R. S & Gbolagade, K. A. (2023). *Framework on Enhancing Biometric Template Storage Module Protection Transformation Scheme Using Residue Number System in Nigeria*. Retrieved from <https://www.researchgate.net/profile/>
- Sekaran, U., & Bougie, R. (2019). *Research Methods for Business: A Skill-Building Approach* (7th ed.). Wiley.
- Tashakkori, A., & Teddlie, C. (2019). *Mixed Methodology: Combining Qualitative and Quantitative Approaches*. SAGE Publications.
- Ubolo, G. O, Kaltume, M. K, Aina, M. L & Aliyu, B. M. (2024). Computerized biometric system and employees' productivity at Murtala Mohammed specialist hospital, Kano State-an empirical study. *Polac management review*, 4(2), 198-217.
- Yin, R. K. (2018). *Case Study Research and Applications: Design and Methods* (6th ed.). SAGE Publications.



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