

Preventive Maintenance and Project Sustainability: A Comparative Study of Public and Private Healthcare Service Organizations in Rivers State

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Abstract

This study compares preventive maintenance practices and project sustainability outcomes between public and private healthcare service organisations in Rivers State, Nigeria. The study aims at examine how ownership type influences maintenance effectiveness. Using a qualitative multiple-case study design with a most similar systems basis for comparison, four hospitals (two public, two private) are compared across six criteria: maintenance frequency, budget allocation, documentation, training, equipment uptime, and perceived sustainability. Thematic comparison and cross-case analysis are used to analyse data from 24 interviews, document analyses, and observations. Private hospitals outperform public hospitals on all criteria: 84%–89% schedule adherence versus 38%–42%, and 3–5 annual generator failures versus 12–14. However, both sectors share common challenges: technician retention difficulties, poor fuel quality, and absence of long-term replacement funds. The comparison reveals that governance structures (procurement autonomy, budget flexibility, and accountability), not staff motivation or technical knowledge explain the performance gap. Theoretical implications offer a synthetic model integrating institutional theory, agency theory, and the resource-based view. Practical implications recommend decentralised procurement and maintenance imprest accounts for public hospitals.

Keywords: preventive maintenance, project sustainability, public-private comparison, healthcare organisations, Qualitative comparative analysis

1. Introduction

Preventive maintenance has emerged as a critical operational strategy for ensuring the longevity, functionality, and reliability of physical assets across industries, including healthcare. In the context of healthcare service organisations, preventive maintenance refers to the systematic inspection, detection, correction, and prevention of incipient failures before they become actual or major failures (Mobley, 2019). Unlike reactive maintenance, which addresses breakdowns after they occur, preventive maintenance is proactive, scheduled, and designed to preserve equipment such as diagnostic machines, power generators, HVAC

systems, and hospital beds. The global healthcare sector has witnessed increasing recognition that poorly maintained infrastructure directly compromises patient safety, service delivery, and overall organisational sustainability (World Health Organization, 2023).

Project sustainability, on the other hand, refers to the capacity of a project to continue delivering benefits over its intended lifespan after initial funding or implementation ends (Bamberger & Cheema, 1990). In healthcare, sustainability encompasses technical, financial, institutional, and social dimensions, ensuring that maintenance practices do not lapse once donors exit or budgets shrink (Silvestri et al., 2020). Across low- and middle-income countries, including Nigeria, many healthcare infrastructure projects have failed prematurely due to neglect of post-implementation maintenance, leading to abandoned equipment and deteriorating facilities (Udoudoh & Ekere, 2022).

Rivers State, a major oil-producing region in Nigeria's South-South geopolitical zone, hosts a mix of public and private healthcare service organisations. Public healthcare facilities are government-owned, funded through budgetary allocations, and often characterised by bureaucratic procurement processes, inconsistent maintenance funding, and high patient volumes. Private healthcare organisations are profit-orientated or non-profit, funded through out-of-pocket payments, insurance schemes, or corporate investments, and typically have more flexible maintenance decision-making structures (Akinwale & Ogundele, 2021). Comparing these two ownership models is useful because they operate under the same macroeconomic and geographical conditions but differ fundamentally in governance, resource access, and accountability mechanisms. Such a comparison can reveal whether ownership type influences the relationship between preventive maintenance practices and project sustainability, an insight that single-sector studies cannot provide.

Despite the recognised importance of preventive maintenance for project sustainability, a puzzling gap exists in both literature and practice: many healthcare projects in Rivers State remain unsustainable, with equipment breakdowns and facility decay occurring within two to five years of completion, even when preventive maintenance plans are included in project designs. Existing studies have produced contradictory findings. Some research suggests that private healthcare organisations achieve higher sustainability outcomes because they have better access to maintenance funds and technical expertise (Okoro &

Nwachukwu, 2020). Other studies indicate that public healthcare organisations, despite bureaucratic inefficiencies, sometimes sustain projects longer due to government guarantees and continued political oversight (Eze & Ogbonna, 2022). What remains unresolved is whether these differences are systematic or context-specific and whether preventive maintenance practices themselves vary meaningfully between public and private organisations in the same state.

Furthermore, existing literature has largely focused on maintenance in manufacturing or transportation sectors, with healthcare receiving less comparative attention. In Rivers State specifically, no known qualitative comparative study has examined how preventive maintenance is actually implemented, including scheduling, resource allocation, record-keeping, and staff training across public and private healthcare service organisations, nor how those practices affect project sustainability outcomes such as equipment uptime, cost efficiency, and service continuity. This gap means policymakers and healthcare managers lack evidence-based guidance on which ownership model's maintenance practices could be cross-learned to improve sustainability across the entire healthcare system.

This study aims to compare preventive maintenance practices (X) and project sustainability (Y) between public healthcare service organisations (Case 1) and private healthcare service organisations (Case 2) in Rivers State, Nigeria, in terms of maintenance scheduling, resource allocation, compliance monitoring, and sustainability outcomes (specific dimensions), to explain the similarities and differences in how maintenance practices influence sustainability, evaluate which ownership model demonstrates more robust maintenance-sustainability linkages, and generate transferable lessons for policy and practice.

Following this introduction, the next session provides a review extant literature on the concepts of preventive maintenance, project sustainability, public healthcare service organization and private healthcare service organization. Also, theories supporting the study were reviewed. The section also, examined prior studies conducted in order to identify gap in literature. The next section explains the methodology including the approach and designed adopted, sampling procedure, data collection and analytical technique. The next section presents the results of the study, while the following section discusses the findings. Finally, conclusion and recommendations were presented in the last section of the study.

2. Literature Review

2.1 Conceptual review

To undertake a meaningful comparison of preventive maintenance and project sustainability across public and private healthcare service organisations, it is essential to first define and delimit the core concepts consistently.

Preventive Maintenance

Preventive maintenance refers to the systematic and planned activities carried out to retain equipment and facilities in a functional state or to restore them to a condition where they can perform their intended functions (British Standards Institution, 2017). According to Okaro and Okafor (2021), preventive maintenance in healthcare includes routine inspections, lubrication, calibration, part replacement, cleaning, and minor repairs conducted on a predetermined schedule rather than in response to a breakdown. This contrasts with corrective maintenance (repair after failure) and predictive maintenance (condition-based intervention). In comparative studies, preventive maintenance must be measured across consistent dimensions such as frequency of scheduled servicing, adherence to manufacturer guidelines, documentation practices, and allocation of dedicated maintenance personnel (Mobley, 2019). Without a uniform definition, comparing public and private organisations becomes conceptually flawed, as each sector might interpret "preventive maintenance" differently.

Project Sustainability

Project sustainability, derives from broader sustainable development discourse and refers to the ability of a project to continue delivering intended benefits over its planned lifespan after external support or initial capital has been withdrawn. Silvestri et al. (2020) identify four dimensions of sustainability relevant to healthcare projects: technical sustainability (equipment continues to function correctly), financial sustainability (funds exist for ongoing maintenance and replacement), institutional sustainability (organisational policies, routines, and accountability structures support continued operation), and social sustainability (staff and users value and care for the infrastructure). In comparative research, sustainability cannot be reduced to a single indicator; rather, researchers must compare how each organization performs across these dimensions. For the present study, "project sustainability" refers specifically to the post-implementation phase of healthcare infrastructure projects (example, hospital building renovations and medical equipment installations) completed between 2018 and 2023, measured by

equipment uptime, breakdown frequency, repair cost trends, and staff-reported continuity of services.

Healthcare Service Organization

Healthcare service organisation, requires careful comparative definition. Public healthcare service organisations are government-owned entities funded primarily through tax revenues and budgetary allocations, operating under civil service regulations, centralized procurement, and political oversight (Akinwale & Ogundele, 2021). Private healthcare service organisations are non-government entities, including for-profit hospitals, faith-based facilities, and private non-profit clinics, funded through patient out-of-pocket payments, private insurance claims, and corporate or donor grants. For the comparison to be valid, this study includes only secondary and tertiary care facilities in both sectors to ensure comparable complexity of equipment and services. Excluding primary health centres and specialised standalone clinics eliminates variability that would confound the comparison. By defining these three concepts consistently across both cases, the study establishes a common conceptual framework within which similarities and differences can be meaningfully interpreted.

2.2 Theoretical review

Two major theoretical perspectives explain why preventive maintenance practices and project sustainability outcomes may vary systematically between public and private healthcare organisations.

Institutional Theory

Institutional theory posits that organisations operate within institutional environments comprising regulations, norms, and cognitive frameworks that shape their structures and practices (DiMaggio & Powell, 1983; Scott, 2014). From an institutional perspective, public healthcare organisations are subject to coercive isomorphism pressures from government regulations, public procurement laws, and audit requirements that mandate certain maintenance procedures regardless of efficiency. Private organisations, conversely, experience mimetic and normative pressures, often imitating successful competitors and adopting professional maintenance standards to signal competence to clients and accrediting bodies. Applying institutional theory to the present comparison suggests that differences in preventive maintenance practices between public and private organisations in Rivers State may arise not from managerial competence per se, but from the distinct institutional logics that govern each sector. Public

organisations may follow bureaucratic, rule-bound maintenance schedules that are documented but inflexible, while private organisations may adopt more adaptive, outcome-focused practices driven by market competition and patient expectations (Eze & Ogbonna, 2022).

Resource-Based View (RBV)

Resource-based view (RBV) argues that organisational performance and sustainability depend on access to valuable, rare, inimitable, and non-substitutable resources (Barney, 1991). Applied to preventive maintenance, RBV suggests that organisations with superior access to financial resources, technical expertise, spare parts inventories, and management information systems will achieve higher sustainability outcomes. Private healthcare organisations, particularly in Rivers State, typically generate revenue from services and may reinvest surplus into maintenance, whereas public organisations depend on annually appropriated budgets that are often released late or reduced (Okoro & Nwachukwu, 2020). However, RBV also recognises that public organisations may possess unique resources unavailable to private ones, such as political protection, access to donor-funded maintenance programmes, and economies of scale across multiple facilities. The comparison between public and private organisations in this study will test whether RBV predictions hold; that is, whether the sector with greater resource flexibility demonstrates superior maintenance practices and sustainability or whether institutional factors override resource advantages.

Complementary Theory

Complementary theory is agency theory, which examines the relationship between principals (owners or funders) and agents (managers). In public healthcare, the principal is the government and ultimately taxpayers, while the agent is hospital management. Bureaucratic distance and multiple layers of oversight can lead to goal divergence, where managers may underinvest in preventive maintenance because benefits are long-term while budgetary pressures are immediate (Jensen & Meckling, 1976). In private healthcare, the principal is typically the owner or board of directors, with shorter lines of accountability, potentially aligning manager and owner interests more closely. Agency theory thus predicts that private organisations will exhibit more consistent preventive maintenance because agents face stronger direct consequences for equipment failure and service disruption. However, agency problems can also exist in private organisations where hired managers prioritise short-term profits over long-term asset preservation (Udoudoh & Ekere, 2022). This study will examine whether

agency theory explains the observed differences between public and private organisations in Rivers State.

2.3 Empirical Review

Previous empirical studies have examined preventive maintenance and sustainability in healthcare, though few have conducted direct qualitative comparisons between public and private organisations in the same geographical context. A quantitative study by Okoro and Nwachukwu (2020) compared maintenance practices in 12 public and 12 private hospitals across three Nigerian states, including Rivers State. Using survey questionnaires, they found that private hospitals allocated 12–18% of annual operating budgets to preventive maintenance compared to 4–7% in public hospitals and that private hospitals reported 40% fewer unplanned equipment breakdowns. However, the study did not explore *why* these differences existed, nor did it examine maintenance processes, record-keeping, or staff training qualitatively. The authors recommended in-depth comparative case studies to uncover mechanisms.

Another comparative study by Akinwale and Ogundele (2021) examined public-private partnerships in Nigerian healthcare infrastructure, finding that sustainability was higher in projects where private operators had contracted maintenance responsibilities. However, this study focused on large-scale infrastructure (operating theatres and diagnostic centres) rather than on routine preventive maintenance. The comparison was primarily financial and contractual, ignoring the day-to-day practices of maintenance technicians and facility managers. Similarly, Eze and Ogbonna (2022) conducted a mixed-methods study of donor-funded health projects in South-South Nigeria, including Rivers State. They found that public facilities receiving donor support initially demonstrated better maintenance practices, but sustainability declined rapidly after donor exit because government recurrent budgets did not absorb maintenance expenses. Private facilities, even without donor support, maintained equipment longer due to internal cost-recovery mechanisms. This study highlighted the importance of ownership structure but did not systematically compare maintenance *processes* (e.g., scheduling, inspection checklists, and spare parts procurement) between sectors.

Internationally, Silvestri *et al.* (2020) reviewed 47 health infrastructure projects across sub-Saharan Africa and found that fewer than 30% had functioning maintenance plans two years post-completion. Their framework emphasised that

technical sustainability requires not only funds but also trained personnel, accessible spare parts, and management commitment. However, their analysis aggregated public and private facilities without comparative disaggregation. A study by Mobley (2019) in the United States compared maintenance effectiveness across public and private hospitals, finding that private hospitals used computerised maintenance management systems (CMMS) more frequently, leading to higher schedule compliance. Yet this finding may not transfer to Rivers State due to differences in technology access, skill levels, and regulatory environments. Together, these empirical studies establish that systematic differences exist between public and private healthcare organisations in maintenance practices and sustainability outcomes, but they leave unexplained *how* and *why* these differences manifest in specific local contexts.

2.4 Gap in literature

Despite the contributions of existing studies, four critical gaps remain that justify the present comparative research. First, most previous comparisons between public and private healthcare organisations have been quantitative, relying on surveys and financial data that measure *what* differences exist but not *how* preventive maintenance is actually practised on the ground. The Nigerian context lacks qualitative comparative studies that examine maintenance routines, decision-making processes, documentation practices, and staff behaviour. Without qualitative depth, policymakers cannot understand which specific practices from the private sector might be transferable to public facilities or which public-sector strengths (e.g., standardised protocols) could benefit private organisations.

Second, existing comparative studies have largely ignored the role of intermediary variables such as maintenance record-keeping systems, staff training frequency, and supervision intensity. Most studies compare budget allocations or breakdown rates directly, without examining the organisational processes that translate resources into sustainable outcomes. This omission means that even when differences are found, the mechanisms remain a "black box", limiting actionable recommendations.

Third, no study has systematically applied institutional theory, the resource-based view, and agency theory together in a comparative qualitative design to explain differences between public and private healthcare maintenance in Rivers State. Previous studies have been largely a theoretical or have applied single frameworks, missing the complementary insights that multiple theories can

provide. For example, institutional theory might explain why public organisations follow rigid procedures, while agency theory might explain why managers underinvest in maintenance, and RBV might explain resource constraints. A combined theoretical lens is needed.

Fourth, geographic and temporal gaps exist. Most Nigerian studies have focused on Lagos, Abuja, or northern states, with limited attention to Rivers State despite its unique characteristics: high revenue from oil but persistent underfunding of public health infrastructure and the presence of both well-resourced private hospitals serving oil industry employees and poorly maintained public facilities serving the general population. Furthermore, studies published before 2018 may not reflect recent changes such as the Rivers State Health Insurance Scheme (launched 2019) and post-COVID-19 maintenance challenges (World Health Organization, 2023). The present study fills these gaps by conducting a qualitative comparative analysis of preventive maintenance and project sustainability in public and private healthcare service organisations in Rivers State, using a multi-theoretical framework and focusing on projects completed between 2018 and 2023.

3. Methodology

This comparative study adopts a qualitative multiple-case study design employing a most similar systems logic (Yin, 2018). What is being compared are preventive maintenance practices and project sustainability outcomes between public healthcare service organisations (government-owned secondary and tertiary hospitals) and private healthcare service organisations (for-profit and non-profit private hospitals providing secondary care) in Rivers State, Nigeria. The basis for comparison is similar starting conditions: public and private organisations in this study operate under identical geographical, climatic, economic, and regulatory environments within the Port Harcourt metropolis, allowing the attribution of observed differences primarily to ownership type rather than to contextual confounders. The criteria for comparison are six fold, applied identically to both sectors: frequency of scheduled maintenance inspections; budget allocation and expenditure on preventive maintenance; maintenance documentation and record-keeping completeness; staff training and technical competence; equipment uptime and breakdown frequency; and perceived sustainability of clinical services. The population comprises all 17 public secondary/tertiary hospitals and 124 registered private secondary-care hospitals in Rivers State as of December 2023 (Rivers State Ministry of Health, 2022). From this population, a purposive

sample of four healthcare service organisations is selected: two public hospitals (one tertiary teaching hospital and one secondary general hospital) and two private hospitals (one for-profit corporate hospital and one non-profit faith-based hospital). These four cases are comparable because they share five matching criteria: all are located within the Port Harcourt metropolis, have bed capacities between 100 and 250, operate 24-hour emergency services requiring reliable power, underwent construction or major renovation between 2015 and 2018, and experience the same unreliable national grid electricity supply. This most similar systems matching approach ensures that the only systematic variation across cases is the ownership type (Gerring, 2017; Seawright & Gerring, 2008). Data were collected through semi-structured interview, document analysis checklist, and observation protocol records equipment condition, spare parts organization, posted schedules, and staff interactions during unannounced site visits. Thematic comparison and cross-case analysis are used to analyse data from 24 interviews, document analyses, and observations

4. Data Presentation and Analysis

This study is purely qualitative in design, and accordingly, no inferential statistical tools (e.g., t-tests, chi-square, or regression) are employed. However, simple descriptive quantification is used where appropriate to show patterns across the data: specifically, the frequency with which particular themes are mentioned across interviews (e.g., “budget constraint” mentioned by 22 of 24 respondents) and the presence or absence of specific document types across the four hospitals. These frequencies are reported as counts and percentages to provide transparency about the prevalence of themes, but they are not subjected to statistical testing. The primary analytical approach is qualitative, organised around two complementary strategies: thematic comparison and cross-case analysis, following the procedures recommended by Braun and Clarke (2021) for thematic analysis in comparative qualitative research and by Miles, Huberman, and Saldaña (2020) for cross-case display matrices.

All interview transcripts, document summaries, and observation field notes from the four hospitals (two public, two private) are analysed. Data are first coded using a hybrid approach: deductive codes derived from the six comparison criteria (maintenance frequency, budget allocation, documentation, training, equipment uptime, and perceived sustainability) and inductive codes that emerge from the data (e.g., “fear of audit” in public hospitals and “client pressure” in private hospitals). Coding is conducted systematically across all four cases by the lead

researcher, and a second researcher independently codes 20% of the data to verify consistency, achieving an inter-coder agreement of 87% (O'Connor & Joffe, 2020). After coding, data are organised into thematic matrices and case-ordered displays to facilitate systematic comparisons.

4.1 Thematic comparison

Thematic comparison involves identifying recurrent themes across the dataset and then examining how each theme is expressed similarly or differently between public and private healthcare organisations. Through iterative reading and coding, six major themes emerge that correspond closely to the predefined comparison criteria, along with two unexpected themes. Each theme is presented below by first defining it, then showing its manifestation in public hospitals (both cases combined), then in private hospitals, and finally highlighting similarities and differences.

Theme 1: Scheduled Maintenance Frequency

This theme captures how often organisations conduct planned inspections, lubrication, calibration, and part replacement on critical equipment (generators, sterilisers, and imaging devices). In both public hospitals, scheduled maintenance follows a fixed monthly or quarterly calendar mandated by the Rivers State Ministry of Works and Hospital Engineering Department. Maintenance logs were reviewed from Public Hospital A showing generator servicing every 250 running hours (approximately monthly) and steriliser calibration every three months. But interviews with the heads of maintenance at both public hospitals show that schedules are often "honoured more in paperwork than in practice" (Public Hospital A, Head of Maintenance) because there aren't enough staff to perform proactive repairs. Document analysis confirms that while schedules exist, completion rates are low: only 42% of scheduled inspections in Public Hospital A and 38% in Public Hospital B were fully completed over the previous 12 months. In contrast, both private hospitals demonstrate higher schedule adherence. Private Hospital A (for-profit) uses a computerised maintenance management system that generates automatic work orders, and observation confirms that checklists are signed and dated at each inspection. Private Hospital B (non-profit) maintains a paper-based system but employs a dedicated maintenance supervisor who conducts spot checks; document analysis shows completion rates of 89% and 84%, respectively. A striking similarity is that all four hospitals schedule generator servicing monthly—driven by the unreliable power grid common to Rivers State. The key difference lies in adherence: private hospitals achieve near-

full compliance, while public hospitals experience significant gaps between planning and execution.

Theme 2: Budget Allocation and Expenditure Constraints

This theme refers to the availability and actual spending of funds for preventive maintenance activities. Across both public hospitals, maintenance is funded through the government's annual recurrent budget, but interviews with procurement officers reveal chronic delays in fund release. One respondent stated, "Our budget for 2023 was approved in June, and by December we had received only 40%" (Public Hospital B, Procurement Officer). Document analysis confirms that budget releases average 45–55% of approved amounts across the 2018–2023 period. Furthermore, unspent maintenance funds must be returned to the state treasury at year-end, creating a "use-it-or-lose-it" dynamic that discourages long-term planning. Public hospital maintenance managers report relying on emergency memos for critical repairs rather than routine preventive allocations. Private hospitals exhibit a different pattern: both allocate 12–18% of operating budgets to maintenance, but more importantly, funds are accessible throughout the year. The for-profit private hospital has a separate maintenance reserve account, while the non-profit hospital relies on a maintenance levy from service revenues. A similarity across both sectors is that all four hospitals report that spare parts procurement is the single largest budget challenge, especially for imported equipment. However, private hospitals overcome these challenges through direct supplier relationships and credit arrangements, whereas public hospitals must go through a centralized procurement bureau, causing delays of three to six months.

Theme 3: Documentation and Record-Keeping Practices

This theme captures the availability, completeness, and accessibility of maintenance logs, work orders, equipment histories, and inspection checklists. A stark divergence emerges between sectors. Public hospitals maintain extensive documentation in the form of bound logbooks and file folders, driven by audit requirements from the Ministry of Health. Observation in Public Hospital A shows a dedicated records room with maintenance files going back 15 years. However, the usefulness of this documentation is limited: logs are often incomplete, entries lack signatures, and equipment histories are not digitised, making trend analysis impossible. One technician noted, "We fill the books because we have to, but no one ever reads them" (Public Hospital A, Senior Technician). Private hospitals, conversely, maintain leaner but more functional

documentation. Private Hospital A uses a cloud-based maintenance software where every inspection generates a digital timestamp and photo evidence. Private Hospital B uses a structured paper system where checklists are filed in equipment-specific binders and reviewed monthly by management. The similarity is that all four hospitals keep some form of written record; the difference lies in purpose (compliance vs. utility) and accessibility (locked filing cabinets vs. technician-friendly systems).

Theme 4: Staff Training and Technical Competence

This theme refers to formal training programmes for maintenance personnel and the perceived competence of staff in performing preventive tasks. In public hospitals, training is centralized: the Ministry of Health organises annual workshops for biomedical engineers and technicians, often funded by donors. However, interviews reveal that training attendance is inconsistent due to competing duties, and trained staff are frequently reassigned to administrative roles, losing their technical skills. Additionally, public hospitals experience high turnover of maintenance staff due to civil service transfers. One respondent lamented, “We train someone for two years, and then they are posted to a different hospital” (Public Hospital B, Head of Maintenance). In private hospitals, training is facility-specific and more frequent: both private hospitals conduct quarterly in-house training sessions, and the for-profit hospital sponsors staff for external certification courses. Private Hospital B has a mentorship system where senior technicians train juniors on specific equipment. A similarity is that all four hospitals report difficulty retaining skilled biomedical engineers due to emigration (“brain drain”) and competition from oil companies offering higher salaries. However, private hospitals mitigate the issue through retention bonuses and career progression pathways, whereas public hospitals rely on government pay scales that cannot compete.

Theme 5: Equipment Uptime and Breakdown Frequency

This theme captures the operational reliability of critical equipment as reported by clinical staff and verified against maintenance logs. Clinical staff in public hospitals report frequent, disruptive breakdowns. A nurse in Public Hospital A stated, “Our steriliser breaks down at least once a month, and we have to send instruments to the private hospital down the road.” Document analysis of breakdown logs indicates that Public Hospital A, experienced 14 unplanned generator failures and 11 steriliser breakdowns in 2023, with an average downtime of 3.2 days per event. Public Hospital B had similar figures. In contrast,

private hospitals report fewer and shorter disruptions. Private Hospital A recorded three generator failures and two steriliser breakdowns in 2023, with an average downtime of 0.8 days. Private Hospital B recorded 5 failures and 4 breakdowns, with an average downtime. A similarity is that generator failures correlate strongly with poor fuel quality (a common issue in Rivers State) across all four hospitals. The difference is that private hospitals maintain on-site fuel filtration systems and larger fuel reserves, while public hospitals rely on just-in-time fuel purchases that are often delayed.

Theme 6: Perceived Sustainability of Clinical Services

This theme captures the subjective assessment by facility managers and clinical staff of whether core services can continue without major external intervention. Public hospitals perceive sustainability as fragile. Both public hospital medical directors express concern that if donor-supported maintenance programmes end or if government budgets tighten further, equipment failure rates will escalate. One director stated, “We are running on goodwill and the personal dedication of our technicians, not on a sustainable system” (Public Hospital A, Medical Director). In private hospitals, sustainability perceptions are more optimistic. The for-profit hospital views maintenance as a core business function tied to patient revenue and reputation; sustainability is therefore built into the business model. The non-profit hospital acknowledges challenges but notes that their board has committed to a 10-year maintenance reserve fund. A similarity across all four hospitals is that none have a fully documented sustainability plan beyond the current financial year. The difference lies in the underlying confidence: private managers believe they can adapt, while public managers feel trapped by bureaucratic structures beyond their control.

Two unexpected themes also emerge from the analysis. First, “political interference in maintenance” is mentioned exclusively by public hospital respondents, who report that equipment purchases and maintenance contracts are sometimes awarded to political allies rather than the most qualified vendors, resulting in substandard spare parts. Second, only private hospital respondents talk about “patient pressure as a maintenance driver.” They say that paying patients complain loudly when equipment breaks, which puts immediate pressure on management to repair it. In public hospitals, where services are subsidized, patient complaints are less significant. These unexpected themes illuminate deeper mechanisms underlying the observed differences.

4.2 Cross-case analysis

While thematic comparison examines each theme vertically across sectors, cross-case analysis synthesises findings by comparing cases systematically across all six criteria simultaneously, using a matrix display as recommended by Miles, Huberman, and Saldaña (2020). The matrix below presents each hospital's performance on each criterion, followed by a narrative synthesis explaining the patterns.

Comparative Matrix: Preventive Maintenance and Sustainability across Four Hospitals

Criterion	Public Hospital A (Tertiary)	Public Hospital B (Secondary)	Private Hospital A (For-profit)	Private Hospital B (Non-profit)
Maintenance schedule adherence	Low (42% completion)	Lo (38% completion)	High (89% completion)	High (84% completion)
Budget allocation & expenditure	45-55% of approved released	40-50% released	15% of operating budget	12% of operating budget
Documentation quality	Extensive but non-functional	Extensive but non-functional	Lean, digital, functional	Lean, paper, functional
Staff training frequency	Annual (donor-dependent)	Annual (donor-dependent)	Quarterly + external certs	Quarterly in-house
Equipment uptime (breakdowns/year)	14 gen, 11 sterilizers	12 gen, 9 sterilizers	3 gen, 2 sterilizers	5 gen, 4 sterilizers
Perceived sustainability	Fragile, system-dependent	Fragile, system-dependent	Secure, business-model dependent	Moderate, reserve-dependent

The cross-case analysis reveals three major patterns. First, a clear sectoral divide exists: the two public hospitals cluster together on all six criteria, and the two private hospitals cluster together. Public hospitals uniformly exhibit low schedule adherence, constrained budget access, documentation that serves compliance rather than function, donor-dependent training, high breakdown frequency, and fragile sustainability perceptions. Private hospitals uniformly exhibit high schedule adherence, dedicated and accessible maintenance budgets, functional documentation (whether digital or paper), regular training, low breakdown frequency, and more secure sustainability perceptions. This pattern strongly

suggests that ownership type, public versus private, is the primary differentiator, rather than hospital size (tertiary vs. secondary) or profit orientation (for-profit vs. non-profit) since within-sector variation is minimal.

Second, the relationship between criteria is causal and cumulative rather than isolated. In private hospitals, adequate budget access enables timely spare parts procurement, which enables high schedule adherence, which reduces breakdowns, which reinforces positive sustainability perceptions. The reverse causal chain operates in public hospitals: constrained and delayed budget releases lead to missing spare parts, which prevents completion of scheduled maintenance, which increases breakdowns, which erodes sustainability perceptions. This cumulative causation suggests that interventions targeting a single criterion (example, training alone) without addressing budget access are unlikely to succeed in public hospitals. As one public hospital technician stated, “You can train me every month, but if I do not have a spare part on the shelf, the machine stays broken.”

Third, a surprising cross-cutting similarity emerges regarding planning horizons. Despite their superior performance on most criteria, private hospitals share with public hospitals a lack of long-term (beyond five years) maintenance planning. Neither sector has a formal asset replacement fund or a predictive maintenance program based on equipment degradation modelling. Both sectors operate largely on reactive-to-scheduled maintenance, with private hospitals simply executing the scheduled component more faithfully. This suggests that even the best-performing private hospitals have not yet reached international best practice (example, condition-based maintenance), leaving room for improvement across both sectors.

The cross-case analysis also tests the theoretical frameworks introduced in the literature review. Institutional theory predicts that public hospitals would exhibit bureaucratic, rule-bound practices, as evidenced by their extensive but non-functional documentation and centralized procurement constraints. Agency theory predicts that private hospitals would show stronger principal-agent alignment, confirmed by the fact that private managers face direct consequences (loss of patients, revenue) for maintenance failures. The resource-based view predicts that private hospitals’ superior resource flexibility (accessible budgets, supplier relationships) explains their better outcomes, which is also confirmed. However, the analysis also reveals that no single theory fully explains all observations: institutional pressures explain *why* public hospitals maintain use less documentation, but agency theory explains *why* they cannot easily abandon it (the

principal government requires it), and RBV explains *why* private hospitals can afford functional systems. A synthetic theoretical model is therefore proposed in the discussion.

In summary, the data presentation and analysis demonstrate that preventive maintenance practices and project sustainability outcomes differ systematically between public and private healthcare organisations in Rivers State across all six comparison criteria, with the private sector outperforming the public sector. However, both sectors share a common weakness in long-term planning, and the causal mechanisms underlying the differences are cumulative rather than isolated. The discussion section now interprets these findings in light of previous literature and theoretical implications.

4.3 Discussion of Findings

Similarities and differences across compared units

Similarities

Four commonalities emerge across the four healthcare organisations studied. First, all recognise preventive maintenance as critically important; the problem is not ignorance but implementation capacity. Second, all four struggle to retain skilled biomedical engineers due to competition from Rivers State's oil and gas industry, which offers substantially higher salaries. Third, generator failures across all hospitals correlate with poor fuel quality, a ubiquitous problem in the region. Fourth, none of the hospitals has a formal long-term asset replacement fund or predictive maintenance program extending beyond five years, indicating short planning horizons in both sectors.

Differences

The divergences between public and private organisations are more pronounced. Regarding schedule adherence, private hospitals complete 84–89% of scheduled preventive maintenance tasks, while public hospitals complete only 38–42%. This gap is explained by structural factors: public hospitals face centralized procurement delays of three to six months for spare parts, whereas private hospitals maintain direct supplier relationships. Regarding budget access, public hospitals receive only 40–55% of approved maintenance budgets due to delayed and erratic fund releases, while private hospitals access 100% of allocated funds year-round. Regarding documentation utility, public hospitals maintain extensive but non-functional paperwork driven by audit compliance, while private hospitals

keep leaner, functional systems that technicians actually use. Regarding sustainability perceptions, public hospital managers view sustainability as fragile and system-dependent, while private managers see it as secure and business-model-dependent. Ownership type and its associated governance structures, institutional pressures, and accountability mechanisms, all operating within the same Rivers State context, account for these differences.

Comparison of findings with previous studies

The present findings confirm several earlier studies. The finding that private hospitals allocate 12–18% of operating budgets to maintenance versus 4–7% effective allocation in public hospitals directly confirms Okoro and Nwachukwu's (2020) quantitative survey of Nigerian hospitals, while adding qualitative explanation of *why* this gap persists (budget release delays and procurement bottlenecks). The finding that private hospitals experience fewer unplanned breakdowns (3–5 generator failures annually versus 12–14 in public hospitals) confirms Eze and Ogbonna's (2022) mixed-methods study in South-South Nigeria. The observation that public hospitals maintain extensive but non-functional documentation aligns with Akinwale and Ogundele's (2021) findings on bureaucratic ritualism in Nigerian public health facilities.

However, the study contradicts Mobley's (2019) claim, based on US data, that non-profit private hospitals perform worse than for-profit hospitals on maintenance metrics. In Rivers State, the non-profit private hospital performed nearly as well as its for-profit counterpart on all criteria, suggesting that non-profit status does not inherently disadvantage maintenance in low-middle-income contexts. The study also contradicts the "training-first" assumption common in donor-funded health projects (World Health Organisation, 2023): public hospital technicians are often well-trained but cannot perform maintenance when spare parts are unavailable due to procurement delays. Finally, the study refines Silvestri et al.'s (2020) sustainability framework by demonstrating that its four dimensions (technical, financial, institutional, and social) interact in sector-specific ways, with causal ordering and feedback loops that vary by ownership type.

4.4 Theoretical implications

The results corroborate, contest, and enhance three theoretical frameworks. Institutional theory is supported in predicting that public hospitals adopt maintenance practices (extensive documentation) in response to coercive

pressures from the Ministry of Health (DiMaggio & Powell, 1983; Scott, 2014). However, the theory is challenged in that isomorphic pressures produce uniform *practices* but not uniform *outcomes*: both public hospitals have similar documentation, but different resource levels affect their effectiveness. The refinement of the theory demonstrates that institutional forces shape the form of practices, while resource-based explanations are necessary to understand their effectiveness.

Agency theory is supported in that private hospitals exhibit stronger principal-agent alignment (owners face direct consequences for failures), while public hospitals suffer from diffuse accountability (Jensen & Meckling, 1976). However, the theory is challenged by the finding that public hospital staff often work diligently despite weak incentives, suggesting intrinsic motivation and professional ethics partially substitute for formal accountability. The theory is refined by incorporating intrinsic motivation as a moderator that reduces but does not eliminate agency problems.

The resource-based view (RBV) is supported in that private hospitals' superior sustainability outcomes are explained by resources public hospitals lack: flexible financial reserves, direct supplier relationships, and functional information systems (Barney, 1991). However, RBV is challenged by the finding that static resource endowments are insufficient; Private Hospital B achieves similar results with paper systems because it possesses dynamic capabilities (supervision and accountability routines). The theory is refined by integrating dynamic capabilities the ability to reconfigure resources and routines in response to conditions (Teece, 2018).

Synthetic theoretical implication. The comparison suggests that no single theory adequately explains the public-private divide. A synthetic model is proposed: institutional logics determine the rules of the game (accountability structures and procurement systems); these shape agency relationships (strong or weak alignment), which in turn determine dynamic capabilities (ability to adapt); and finally, dynamic capabilities determine how effectively resources are deployed for maintenance and sustainability. This model explains why training alone fails in public hospitals without addressing procurement constraints and why private non-profit hospitals perform well despite fewer resources: they possess private-sector institutional logics that enable dynamic capabilities.

5. Conclusion and Recommendations Conclusion

The most striking finding is that private hospitals consistently outperform public hospitals across all six criteria, yet the two sectors share important common challenges. Public hospitals complete only 38–42% of scheduled maintenance tasks, receive only 40–55% of approved maintenance budgets, maintain extensive but non-functional documentation, experience 12–14 generator failures annually, and perceive sustainability as fragile. Private hospitals, conversely, complete 84–89% of scheduled tasks, access 100% of allocated funds, maintain lean functional documentation, experience only 3–5 generator failures annually, and perceive sustainability as secure. However, both sectors share four similarities: universal recognition of maintenance as important, difficulty retaining skilled technicians due to oil industry competition, generator failures linked to poor regional fuel quality, and absence of long-term asset replacement funds or predictive maintenance programmes. In short, private hospitals achieve better sustainability through more reliable implementation of maintenance routines, but neither sector has solved the underlying problem of short-term planning horizons.

The comparison reveals that ownership type is not merely a label but a fundamental determinant of the institutional logic, accountability structure, and dynamic capabilities that shape maintenance outcomes. The more profound insight is that structural constraints, not individual motivation or technical knowledge, are the primary barrier to preventive maintenance in public hospitals. Technicians at public hospitals are often well-trained and dedicated, but they can't do scheduled maintenance when spare parts take six months to arrive through centralised procurement or when budget releases cover less than half of what was approved. Conversely, private hospitals succeed not because their staff are more skilled, but because their governance structures allow flexible resource deployment, direct supplier relationships, and rapid response to equipment failures. The comparison further reveals that similarities across sectors arise from shared contextual factors (labour market, fuel quality, and equipment supply chains), while differences arise from ownership-specific institutional arrangements. This implies that transplanting private-sector practices into public hospitals without changing the underlying procurement and budget systems is unlikely to succeed. Finally, the comparison reveals that non-profit private hospitals can perform nearly as well as for-profit ones when they operate under private-sector institutional logics, challenging assumptions that a profit motive is

necessary for maintenance effectiveness. The overarching revelation is that sustainable healthcare infrastructure requires not just resources or training, but governance systems that enable timely, flexible, and accountable maintenance decision-making.

Recommendations

Based on the comparative findings, the following recommendations are proposed.

- a) Public hospital maintenance managers should adopt two private-sector practices: implement visual inventory management with minimum stock thresholds to trigger immediate reordering, and establish direct relationships with local "emergency vendors" under existing procurement rules to reduce six-month spare parts delays.
- b) Private hospital managers should formalise long-term asset replacement funds beyond the current year, as neither private hospital in the study had a five-year maintenance plan. Both sectors should jointly negotiate with fuel suppliers or invest in shared fuel filtration infrastructure to address the common problem of poor fuel quality causing generator failures.
- c) The Rivers State Ministry of Health should decentralise spare parts procurement for common items to the hospital level and create "maintenance imprest accounts" allowing public hospital managers to access up to 30% of annual maintenance budgets without centralized approval, with quarterly post-expenditure audits.
- d) Additionally, all donor-funded health projects should include a legally binding maintenance endowment fund (a minimum of 15% of project costs) modelled on private non-profit reserves.
- e) For private hospitals, policymakers should introduce incentive schemes (example, accelerated licensing renewals) that reward facilities with over 80% adherence to maintenance schedules.

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