



WASTE MANAGEMENT COSTS AND HOSPITAL PERFORMANCE: EVIDENCE FROM FEDERAL PUBLIC HEALTHCARE FACILITIES IN SOUTH-SOUTH, NIGERIA

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Abstract: The study examined the relationship between waste management costs and hospital performance in tertiary health care facilities in the South-South, Nigeria. The descriptive research design was employed for the study and three tertiary healthcare facilities in the region were studied. The proxies for waste management cost were collection cost, transportation cost and disposal cost while hospital performance was proxied by patient length of stay, revenue generated, and staff-patient ratio. The results showed that collection and disposal cost had a positive and significant relationship with patient length of stay while both transportation and disposal costs showed significant relationship with revenue generated but disposal costs had a negative coefficient. Also, collection cost and disposal cost had positive and significant relationships with staff to patient ratio. The findings indicate that waste management cost components exert differential effects on key performance proxies within public health institutions in Nigeria's South-South region. Therefore, there is necessity for an integrated, efficient, and context-sensitive waste management systems in public health institutions for environmental safety as well as economic and operational efficiency.

Keywords: *Waste management costs, hospital performance, health care facilities.*

1. Introduction

The performance of health facilities has traditionally been examined through the lens of performance management and evaluation frameworks. Service delivery processes in hospital settings are generally more structured and measurable compared to other segments of the



healthcare system. Hospitals are saddled with the dual responsibility of managing acute and chronic health conditions, making them critical in the overall assessment of health system

efficiency and responsiveness. In response to evolving public sector reforms, hospitals have increasingly adopted performance management tools aimed at enhancing service delivery and optimizing resource use. According to Mascia and Vincenzo (2011), hospital performance is commonly interpreted as the ability to maximize service output with available resources while maintaining financial sustainability. Metrics such as patient mortality rates, bed occupancy rates, service growth, cost efficiency, employee turnover, and resource utilization are frequently used to evaluate the operational effectiveness of healthcare institutions (Olusa & Oladele, 2024; Ziraba et al., 2022; Valerie, 2015). Unlike other sectors of the economy, hospital management faces the unique challenge of balancing high standards of clinical care with financial prudence, where lapses in efficiency may directly result in loss of lives. One significant but often under-explored area of hospital performance relates to waste management. The Federal Ministry of Environment (2005) observed that rapid urbanization and industrial growth in Nigeria have outpaced the capacity for effective waste collection, transport, and disposal, particularly in public institutions. This challenge is evident in the health sector, where inefficient waste management leads to indiscriminate dumping, environmental degradation, and increased exposure to diseases. In many teaching hospitals, waste streams include significant volumes of biodegradable and non-biodegradable materials, the latter posing a particular threat due to their resistance to decomposition and environmental persistence.

Globally, disparities in health outcomes across countries with similar socio-economic profiles is attributed, in part, to differences in health system performance. Institutional design, policy content, and system management strategies play critical roles in shaping socially desirable outcomes such as equity, responsiveness, and quality of care. To address these disparities, decision-makers require robust, comparable data on system performance and its determinants both at national and subnational levels. Health system performance assessment must therefore include analyses of subsystems such as hospitals, and consider both financial and non-financial performance indicators, including revenue generation, staff-to-patient ratios, and average patient length of stay. Existing literature often falls short by either listing numerous overlapping indicators without analytical clarity or relying on easily accessible data that may inadequately capture performance complexity. A systematic understanding of health system performance



must extend to include explanatory factors, especially cost-related elements like waste management. Given the labour and capital-intensive nature of waste collection, transportation, and disposal, inefficiencies in these processes can significantly influence hospital operations. Given the increasing complexity of healthcare delivery, driven by demographic shifts, the rising burden of chronic diseases, and limited resources, efficient hospital waste management is not merely an environmental concern but a fundamental operational imperative. Inadequate waste disposal systems can trigger patient dissatisfaction, delayed recovery, and even voluntary discharge against medical advice, all of which reduce overall institutional performance (Roodpeyma & Hoseyni, 2010). Furthermore, the substandard state of hygiene and waste control in many public hospitals is a major reason why patients often prefer private facilities despite the latter's higher costs. Waste management costs have been analyzed through various lenses such as life cycle cost analysis, segregation and classification costs, transportation and disposal expenditures, and costs associated with recycling and reuse (Mosquera et al., 2014; Tudor et al., 2008).

Empirical studies on waste management in the healthcare sector of Nigeria have focused mostly on waste generations rates, regulatory compliance, staff awareness and waste segregation practices across both private and public hospitals. These studies outlined insights into the volume and handling of healthcare waste and also identified key challenges of the sector to include infrastructural challenges, training deficiencies and weak enforcement mechanisms (Awodele et al., 2016; Olusa & Oladele, 2024; Udejaja et al., 2023).

Some have attempted linking hospital waste disposal to performance -related outcomes. Olusa and Oladele (2024) quantified hospital waste generated per kilogram (KG) per bed per day and found poor waste segregation practices and poor handling were consequences of underfunding and limited infrastructure. Furthermore, existing literature predominantly focus on non-financial indicators of healthcare performance in the context of waste management. Although these metrics are essential for assessing operational efficiency and public health impact, they do not fully capture the economic sustainability of healthcare institutions. Notably, few studies incorporate direct financial metrics such as hospital revenue or cost savings resulting from improved waste practices. This study addresses this gap by integrating a financial performance metric revenue into the analysis, alongside non-financial indicators such as patient length of stay and staff-to-patient ratio. Furthermore, the study simplifies the broad categorization of



waste management costs into three core cost components: (i) collection costs, including generation, segregation, classification, and processing; (ii) transportation costs, encompassing handling and storage; and (iii) disposal costs, which include recycling and reuse strategies. This streamlined approach offers a more targeted and comprehensive framework for evaluating the cost-performance relationship of hospital waste management systems with the aim of providing evidence-based insights for hospital administrators and policymakers.

2. Literature Review

Performance of Public Hospitals

The concept of performance within healthcare system remains a multi-dimensional and subjectively interpreted concept across literature. Scholars often relate performance to environmental, organizational, and stakeholder-driven contexts. Grüning (2002) highlights the role of goal attainment and contextual goal-setting as integral to defining organizational performance. Krause (2005) extends this perspective by emphasizing the extent to which an institution meets the expectations of its relevant stakeholders. Neely et al. (2022) argue that performance should encapsulate both efficiency and effectiveness, measured qualitatively and quantitatively. This aligns with public sector interpretations, where performance is assessed not only in terms of fiscal outcomes but also the alignment between goals, means, and results (Matei, 2006).

In the healthcare sector, performance encompasses clinical outcomes, operational efficiency, and social accountability. Hospitals are considered value creators when they deliver timely and cost-effective care while ensuring positive patient outcomes. Thus, performance measures in healthcare extend beyond financial metrics to include patient-centric and equity-focused dimensions (Kruk et al., 2018; WHO, 2022). In line with this, this study operationalized public hospital performance using indicators such as patient length of stay, hospital revenue, and the proportion of patients leaving against medical advice. Hospitals and healthcare organizations use numerous performance metrics across operations, finance, and communication.

2.1 Theoretical framework

This study is anchored on Waste Management Theory and Strategic Choice Theory. The Theory of Waste Management, as advanced by Pongrácz et al. (2004), offers a comprehensive conceptualization of waste, the activities associated with its handling, and the overarching



goals of sustainable waste practices. Central to the theory is the view that waste, defined as any object that lacks immediate value or utility to its owner, must be managed in ways that prevent harm to human health and the environment (Pongrácz, 2002). Waste management, therefore, is more than a reactive process; it involves a structured methodology encompassing collection, transportation, recovery, and final disposal of discarded materials. The theory provides not just operational definitions of waste and waste management activities, but also outlines a strategic orientation towards resource conservation and environmental protection. It emphasizes that management decisions must occur within constraints defined by legislative, technical, and ecological boundaries. Thus, waste management should be guided by predefined, sustainable options that minimize toxicity, maximize recoverability, and support long-term ecological balance. Furthermore, the theory underscores the importance of precise conceptual definitions, as the way waste is defined influences the actions taken upon it. Consequently, the theory functions both as a descriptive and prescriptive framework: it clarifies terminology, guides decision-making, predicts outcomes of various waste treatment strategies, and supports the development of policies and legislation aimed at improving waste handling practices. The theory advocates for an integrative and systematic approach that aligns waste treatment choices with environmental and public health objectives.

Strategic Choice Theory as proposed by Child (1972), emphasizes the pivotal role of managerial discretion in shaping organizational outcomes. The theory posits that organizational performance is not solely a function of environmental conditions but is significantly influenced by the strategic decisions made by top management. These choices often involve navigating constraints related to resources, operational scale, and technological adoption. The theory acknowledges the dynamic interplay between organizational structure and external influences such as suppliers, regulators, and technological advancements. Managers are viewed as active agents who adapt organizational processes in response to both internal demands and external pressures (Ketchen & Hult, 2007). For instance, in the context of healthcare waste management, decisions regarding procurement systems, waste handling technology, and cost allocation are strategic in nature and carry direct implications for institutional efficiency and performance. The theory provides a valuable lens for examining how health institutions and their managers navigate the complexities of performance optimization amidst environmental and institutional constraints.



Waste Management Costs and Healthcare Performance

Effective healthcare waste management (HCWM) has been increasingly recognized as an essential contributor to improved hospital performance, operational efficiency, and environmental sustainability. A growing body of research supports the view that appropriate segregation of general and infectious waste not only mitigates health hazards but also reduces overall costs. Notably, the treatment and disposal costs for infectious or hazardous medical waste are estimated to be five to ten times higher than those of non-hazardous waste (Debere et al., 2021; Ranjan et al., 2023). Thus, enhancing waste segregation protocols could help minimize treatment costs while ensuring regulatory compliance. However, some studies highlight the financial strain between environmental responsibility and operational viability. For example, Johnson et al. (2013) noted that comprehensive waste segregation practices can initially raise hospital expenditures especially in budget-constrained institutions while drawing increased attention from regulatory bodies and civil society concerned with hospital-generated pollution. Hospitals are major producers of healthcare waste, and waste generation profiles often vary by geographic location, hospital size, and specialty. Proper management of this waste stream is essential to avoid adverse health and ecological outcomes (Rahman et al., 2022). In their study on patient safety and hospital efficiency, Paradis et al. (2009) emphasized that patient safety incidents often correlated with poor environmental conditions are associated with longer hospital stays, increased costs, and heightened risk of mortality or readmission. Such events can be identified through voluntary reporting systems and administrative health data, reflecting the broader institutional efficiency, including that of waste handling systems.

Historically, waste management services were instituted primarily to protect public health. Waste collection, as seen and valued by patients has maintained a clearer economic value, as users are directly aware of its utility. In contrast, waste treatment and final disposal are often invisible to patients and staff, leading to undervaluation and underfunding unless supported by legislative frameworks and policy incentives (Mosquera et al., 2014; Rahman et al., 2022).

Reducing pollutant outputs and minimizing the use of hazardous materials during healthcare delivery not only promotes environmental safety but also improves the cleanliness of the facility. A hygienic hospital setting fosters patient recovery, accelerates discharge timelines, and may contribute to increased patient referrals, ultimately boosting revenue (Adeniran et al., 2021). Among the environmental attributes influencing patient perceptions, cleanliness



consistently emerges as a dominant factor. In some cases, dissatisfaction with hygiene has been linked to patients leaving the hospital against medical advice (Roodpeyma & Hoseyni, 2010; Danquah et al., 2020). This association may reflect cultural emphasis on sanitation and heightened awareness of hospital-acquired infections. Hospital administrators can address this challenge through rigorous environmental hygiene policies, strengthening waste disposal systems, and revitalizing infection control committees. These efforts are essential to promoting patient trust and retention, reducing early discharges, and improving overall patient satisfaction and institutional credibility.

Empirical Review

Ali et al. (2016) conducted a life cycle assessment to evaluate hospital waste management strategies in a major Pakistani city, identifying an integrated approach—combining composting, incineration, and material recycling as the most environmentally sustainable and cost-efficient. The study emphasized the influence of transaction costs, including incentives such as reputational benefits and concerns over liabilities, which must be weighed against capital expenditures and staff burden resulting from increased patient loads. Tudor et al. (2008) reported the results of waste minimization trials in healthcare facilities across the UK. They observed an average reduction of 14.8% in general waste and 15.7% in clinical waste, resulting in net cost savings of approximately USD25,000 over one to three years. Their work illustrates that investment in staff education and waste segregation practices can yield significant environmental and economic benefits. Li et al. (2019) applied mathematical modeling to optimize municipal solid waste management under conditions of uncertainty. The model incorporated variables such as generation rates, treatment capacity, and cost of disposal, providing a strategic framework for minimizing system-wide costs. Their approach offers practical applications for healthcare institutions facing similar waste management uncertainties. Abah and Ohimain (2011) examined healthcare waste management practices in a Nigerian tertiary hospital. They reported poor segregation, minimal recycling, and inadequate disposal infrastructure, with only 11.5% of staff trained in proper waste handling. The study concluded that Nigeria's healthcare waste practices were unsustainable, highlighting the need for regulatory reform and workforce capacity building. Ogundele et al. (2018) assessed the public health effects of municipal waste disposal in Ibadan, Nigeria. The study linked improper waste disposal methods to increased community health risks, calling for an integrated waste



management policy supported by public awareness programs and strong governmental oversight.

Alam et al. (2008) conducted a waste characterization study at Chittagong Medical College Hospital in Bangladesh. They observed significant variability in waste volume across wards, with orthopedic departments producing the highest. The study found a strong positive correlation between waste generation and bed occupancy. Due to inadequate treatment options, most waste was dumped in open areas or resold, raising serious environmental and public health concerns.

Johnson et al. (2013) studied healthcare waste segregation in a Central American tertiary-care hospital. They found that 61% of waste in biohazardous bags was non-infectious. After implementing staff training, hazardous waste volumes were reduced by 48%, and correct segregation practices improved by 44%. This demonstrates the value of educational interventions in improving hospital efficiency and reducing costs. Nemathaga et al. (2008) assessed waste practices in two South African hospitals. They found poor classification and handling of waste, with general waste accounting for 60.7% of the total. The study emphasized the need for improved compliance with national guidelines and targeted waste minimization strategies to enhance sustainability and public health.

The above studies reveal diverse methodologies and measurement indicators used in assessing hospital waste management and performance. Researchers employed a range of cost indicators, including segregation, transportation, treatment, recycling, and transaction costs. Performance metrics included patient length of stay, and public health outcomes while some studies focused on non-financial metrics, such as hygiene, patient safety, or environmental risks (Clark, 2018; Johnson et al., 2013). A missing link in existing literature is the limited integration of financial performance indicators, such as hospital revenue, into waste management studies. Specifically, the paucity of studies within the Nigerian context makes it difficult to assess the relationship between waste management cost and hospital performance. This study addressed this by incorporating both financial (revenue) and non-financial indicators (length of stay, staff-to-patient ratio and categorizing waste management costs into three key operational components: collection (segregation, classification), transportation (handling and storage), and disposal (including recycling and reuse). This refined approach supports more strategic decision-making in hospital waste management policy and planning.



3. Methodology

Sample and procedure

This study employed the descriptive research design to examine the effect of waste management costs on the performance of public healthcare institutions in Nigeria's South-South region. This approach was considered appropriate because the variables under investigation are not controlled by the researcher since the events had already occurred. This design enabled the study to explore the causal relationship between the independent and dependent variables based on historical data, without altering existing conditions. The population of the study consisted of the four Federal Teaching Hospitals in the South-South geopolitical zone of Nigeria including the University of Uyo Teaching Hospital, University of Calabar Teaching Hospital, University of Benin Teaching Hospital, and University of Port Harcourt Teaching Hospital. All four institutions were included in the study. Also, these institutions are foremost tertiary training centers for capacity training and medical research in the subregion and being owned by the Federal government to provide tertiary health care to citizens, they serve as appropriate hospitals to provide evidence of the relationships existing between waste management cost and hospital performance. Secondary data constituted the main source of information for the study. These data were extracted from available audited financial records and institutional performance reports obtained directly from the management of each teaching hospital for a ten-year period, 2011 to 2020. The use of official financial documents ensured authenticity and reliability, as these records were prepared according to standard accounting practices and regulatory requirements of Nigeria's public health institutions.

Model specification

To evaluate the relationship between waste management costs (collection cost, transportation cost, and disposal cost) and healthcare performance proxied by patient length of stay, hospital revenue and staff-to-patient ratio. The general model was specified as:

$$Y = \beta_0 + \beta_1 CC + \beta_2 TC + \beta_3 DC + \epsilon$$

$$Y = \alpha + \beta$$



Where:

- Y represents each of the dependent variables (PLS, REV, SPR),
- CC, TC, DC represent collection cost, transportation cost, and disposal cost, respectively,
- β_0 is the constant term,
- $\beta_1, \beta_2, \beta_3$ are the coefficients of the explanatory variables, and
- ε is the stochastic error term.

This general model was then specified into three equations as follows:

1. $PLS = \beta_0 + \beta_1 CC + \beta_2 TC + \beta_3 DC + \varepsilon$
2. $REV = \beta_0 + \beta_1 CC + \beta_2 TC + \beta_3 DC + \varepsilon$
3. $SPR = \beta_0 + \beta_1 CC + \beta_2 TC + \beta_3 DC + \varepsilon$

The expected signs of the coefficients ($\beta_1, \beta_2, \beta_3$) were assumed to be positive, suggesting that improvements in waste management costs would positively influence hospital performance indicators, all things being equal. The measures of the variables are as follows:

PLS - represent patient length of stay measured in terms of the number of days a patient stayed in the hospital.

REV - amount of revenue generated in real terms

SPR - staff patient ratio represents the ratio of medical staff to number of patients

CC - waste collection cost in real terms

TC - waste transportation cost in real terms

DC - waste disposal cost in real terms

Data analysis involved the use of descriptive statistics, correlation matrices, and panel data regression techniques. The regression analysis was performed using Pooled OLS, fixed and random effects models, with the modified Wald test applied to determine the more suitable model for each dependent variable. These statistical procedures provided empirical insights into the nature and magnitude of the relationships among the variables. The scope of the study was limited to a ten-year period (2011–2020) due to data availability and accessibility constraints. Additionally, the literature on the cost-performance relationship in healthcare waste management, particularly within the Nigerian context, was relatively sparse.



4. Results and discussion

The measures of central tendency captured the mean, standard deviation, minimum and maximum values of the variables. The result in Table 1 showed the mean values were: 7.278 for collection cost (CC); 6.944 for transportation cost (TC); 6.365 for disposal cost (DC); 1.858 days for patient length of stay (PLS). 8.720 for revenue (REV); and 0.237 for staff-to-patient ratio (SPR). The standard deviation measured how far the observations are from their sampled averages. The results indicate that standard deviation values were: 0.183 for collection cost (CC); 0.271 for transportation cost (TC); 0.699 for disposal cost (DC); 0.261 days for patient length of stay (PLS). 0.257; for revenue (REV); and 0.155 for staff-to-patient ratio (SPR). Also, the minimum values were: 6.8070 for collection cost (CC); 6.409 for transportation cost (TC); 5.389 for disposal cost (DC); 1.462 days for patient length of stay (PLS); 8.204 for revenue (REV); 0.079 for staff-to-patient ratio (SPR) while the maximum values were: 7.538 for collection cost (CC); 7.480 for transportation cost (TC); 7.671 for disposal cost (DC); 2.408 days for patient length of stay (PLS.); 9.227 for revenue (REV); and 0.7015 for staff-to-patient ratio (SPR).

Table 1

Descriptive Statistics

Variables	Obs	Mean	Std. Dev	Min.	Max.
CC	40	7.278	.183	6.807	7.538
TC	40	6.944	.271	6.409	7.480
DC	40	6.365	.699	5.389	7.671
REV	40	8.720	.257	8.204	9.227
SPR	40	.237	.155	.079	.701
PLS	40	1.858	.261	1.462	2.408

Researcher's computations

A Pearson correlation analysis was conducted to assess the degree of association among the variables under study. A weak, positive, and statistically significant correlation was observed between SPR and CC ($r = 0.046$, $p < .05$), as well as between SPR and TC ($r = 0.261$, $p < .05$). In contrast, SPR displayed a strong, positive, and significant association with disposal cost ($r = 0.785$, $p < .05$). CC also exhibited a high positive correlation with TC ($r = 0.832$, $p = .000$), indicating a strong interdependence between these cost variables. However, the relationship between CC and DC was found to be significantly negative ($r = -0.378$, $p = .016$), suggesting inverse variability between them.



Moreover, CC and PLS were positively but weakly correlated ($r = 0.081$, $p = .618$), indicating no significant association. A strong, significant positive relationship was noted between CC and REV ($r = 0.849$, $p < .05$), whereas the link between CC and SPR remained weak and non-significant ($r = 0.047$, $p = .774$). Similarly, the correlation between TC and disposal cost was negative and statistically non-significant ($r = -0.077$, $p = .635$), and its correlation with PLS was positive but not significant ($r = 0.251$, $p = .118$). However, TC showed a significant, strong, positive relationship with revenue ($r = 0.876$, $p < .001$), but its relationship with SPR was not statistically significant ($r = 0.261$, $p = .103$).

Regarding DC, it showed a significant positive association with PLS ($r = 0.781$, $p < .001$) and SPR ($r = 0.785$, $p < .001$), while its correlation with REV was significantly negative ($r = -0.440$, $p = .005$). Furthermore, the association between REV and SPR was weak and non-significant ($r = -0.055$, $p = .734$), as was the relationship between revenue and PLS ($r = -0.076$, $p = .641$). Finally, a strong, significant and positive correlation was observed between SPR and PLS ($r = 0.963$, $p < .001$), indicating that increases in staff-to-patient ratios were closely aligned with longer hospital stays.

Table 2

Descriptive statistics and correlations matrix

Variables	CC	TC	DC	REV	SPR	PLS
CC	1					
TC	.832*	1				
DC	-.378*	-.077	1			
REV	.849*	.875*	-.440*	1		
SPR	.047	.261	.785*	-.055	1	
PLS	.081	.251	.780*	-.076	.963	1

Researcher's output

To validate the panel regression model, diagnostic tests were conducted to assess key assumptions. Unlike multiple linear regression, panel data models often rely on generalized least squares (GLS) estimators, which inherently satisfy most ordinary least squares (OLS) assumptions (Baltagi, 2005). Normality and linearity were not major concerns in this study due to the log and ratio transformation of variables which reduces the impact of deviations from normality. Heteroskedasticity was tested using the Breusch-Pagan test, which showed no significant evidence of unequal variance across units.



Table 3

Breusch-Pagan /Cook-Weisberg test for heteroscedasticity

Ho: Constant Variance			
models	PLS	REV	SPR
Chi ² (1)	.080	.130	5.240
Prob> Chi ²	.784	.718	.222

Research's computation

Autocorrelation was assessed using the Wooldridge test for first-order serial correlation. The results supported the null hypothesis of no autocorrelation. Additionally, multicollinearity was checked using variance inflation factor (VIF) and tolerance values. All variables fell within acceptable thresholds (VIF < 10, tolerance > 0.10), indicating no multicollinearity issues.

Table 4

Test of Multicollinearity

Variable	REV Model		SPR Model		PLS Model	
	VIF	1/VIF	VIF	1/VIF	VIF	1/VIF
CC	4.800	.208	4.800	.208	4.800	.208
TC	4.140	.241	4.140	.241	4.140	.241
DC	1.480	1.480	1.480	.673	1.480	.673
Mean VIF	3.480		3.480		3.480	

The Breuch Pagan Lagrangian Multiplier test was performed for hospital performance models to select between the pooled (OLS) model and the random effect GLS model. The results were non-significant ($p > .05$) which implied that the pooled (OLS) model was appropriate for all the models (Gujurati & Porter, 2009). Results are shown in Table 5.

Table 5

Lagrangian Multiplier Test of Hospital performance models

Ho: Variance = 0			
Models	REV model	SPR model	PLS model
Chi ² (1)	.000	.000	.000
Prob>Chi ²	1.000	1.000	1.000

Researcher's computations



Patient Length of Stay Model

The pooled ordinary least squares (OLS) analysis for patient length of stay (PLS) as shown on Table 6 indicated that the intercept coefficient was -5.58 and was statistically significant at the 5% level, suggesting that baseline patient stay duration decreased by 5.58% in the absence of waste management cost components. Collection cost ($\beta = 0.85$) exhibited a significant positive influence on PLS, indicating that a 1% increase in collection cost was associated with a 0.85% rise in patient length of stay. This underscores the operational burden of inefficient waste segregation and collection practices on hospital performance. In contrast, transportation cost had a negative coefficient ($\beta = -0.16$), though not statistically significant, implying a marginal reduction in patient stay duration with increasing transportation expenditures. Also, disposal cost ($\beta = 0.37$) showed a statistically significant positive relationship with PLS, suggesting that higher spending on disposal leads to longer inpatient stay.

An R^2 value of 0.7817 indicated that approximately 78.17% of the variation in patient length of stay is explained by variations in waste management cost components (CC, TC, and DC). The Wald Chi-square value (128.94; $p < 0.001$) further confirmed the overall goodness-of-fit of the model. The result is shown on Table 6.

Table 6

Panel Pooled (OLS) regression results for PLS

Variable	COEF.	STD. ERR	Z	P> Z	sig
CC	0.8556558	.2431361	3.520	0.000	significant
TC	-.1652192	.1522741	-1.090	0.278	Non-significant
DC	.2083866	.0354037	10.480	0.000	significant
Constant	-5.584256	1.130211	-4.940	0.000	significant
Wald Chi ² (3): 128.94					
Prob. > Chi ² =0.00					



R-sq: within = 0.5098
between = 0.9881
overall = 0.7817

Panel Pooled (OLS) Analysis for Revenue Model (REV)

The results on Table 7 showed the model had an intercept value was 3.95, which was statistically significant at the 5% level. This suggests that, holding all independent variables constant, the baseline revenue of these hospitals increased by approximately 3.95%, indicating a potentially positive influence of general operational efficiency on institutional earnings.

The coefficient for collection cost was 0.01, suggesting a marginal increase of 0.01% in hospital revenue for every 1% rise in collection-related expenditure. However, this relationship was not statistically significant, indicating that increases in collection cost may not meaningfully drive revenue growth in the context examined. In contrast, transportation cost yielded a positive and statistically significant coefficient of 0.79. This finding implies that a 1% rise in transportation cost is associated with a 0.79% increase in revenue. The result underscores the potential importance of efficient waste transport infrastructure in boosting hospital financial performance, likely by supporting smoother operations and reducing infection risks that could hinder service delivery. Conversely, disposal cost was negatively associated with revenue, with a coefficient of -0.13 , and the result was statistically significant. This suggests that rising disposal costs may erode hospital revenue by approximately 0.13%, likely due to inefficient waste treatment processes or costly disposal practices that do not translate into service or operational gains. The model reported a high coefficient of determination ($R^2 = 0.9062$), indicating that approximately 91% of the variance in hospital revenue was explained by the combined influence of the three waste management cost components (CC, TC, and DC). The Wald Chi-square statistic of 347.79 with a $p < 0.01$ confirms that the overall model is robust and statistically significant at the 5% level, providing a good fit for the data.



Table 7

Panel Pooled (OLS) analysis for REV

Variable	COEF.	STD. ERR	Z	P> Z	Sig.
CC	0.0184969	.1571252	0.12	0.906	Non-significant
TC	.792197	.0984062	8.05	0.000	Significant
DC	-.1362298	.0228794	-5.95	0.000	Significant
Constant	3.951438	.7303918	5.41	0.000	Significant
Wald Chi ² (3): 347.79 Prob. > Chi ² = 0.00					
R-sq: within = 0.8163 between = 0.9753 overall = 0.9062					

Panel Pooled (OLS) analysis Staff-to-Patient Ratio

The results on Table 8 showed an intercept was –3.56 which was statistically significant at the $p < 0.05$, indicating that in the absence of changes in waste management costs, the staff-to-patient ratio was expected to decline by approximately 3.56%. This suggests an inverse baseline relationship between institutional waste expenditure and available human resources relative to patients.

Regarding the specific predictors, the coefficient for collection cost was 0.34 and statistically significant ($p < 0.05$), implying that a 1% increase in collection-related expenditures corresponded to a 0.34% increase in the staff-to-patient ratio. This may reflect the potential operational benefits of improved collection systems in supporting more balanced staff workloads or reduced contamination risks. The coefficient for transportation cost was positive but very small (0.00004) and statistically non-significant, suggesting that fluctuations in transport expenditures did not meaningfully affect the staff-to-patient ratio during the study period. Although directionally positive, this finding lacks practical impact due to its minimal effect size and lack of significance. Disposal cost yielded a coefficient of 0.20, which was statistically significant, indicating that a 1% increase in disposal spending was associated with a 0.20% increase in the staff-to-patient ratio. This result suggests that more efficient or safer



disposal methods may indirectly support better staffing outcomes, possibly by improving workplace safety or workflow conditions.

The model's R^2 value was 0.7541, meaning that approximately 75.41% of the variance in staff-to-patient ratio was explained by the three cost variables. The Wald Chi-square value of 110.41 and its associated p-value (0.0000) confirmed the overall goodness of fit and robustness of the model.

Panel Pooled (OLS) regression test for staff -to- patient ratio

Variable	COEF.	STD. ERR	Z	P> Z	Sig.
CC	0.340741	.1538561	2.21	0.027	significant
TC	.0000409	.0963588	0.00	1.000	Non-significant
DC	.2083866	.0224034	9.30	0.000	significant
Constant	-3.569296	.7151957	-4.99	0.000	significant
Wald Chi ² (3): 110.41					
Prob. > Chi ² = 0.00					
R-sq: within = 0.4434					
between = 0.9853					
overall = 0.7541					

The findings from this study indicate that waste management cost components exert differential effects on key performance proxies within public health institutions in Nigeria's South-South region. The regression analysis showed that collection cost had a positive but statistically non-significant effect on hospital revenue, while transportation cost was found to have a positive and significant impact. Conversely, disposal cost displayed a negative and significant relationship with revenue. These results partially align with Tudor et al. (2008), who reported that strategic waste minimization efforts in healthcare facilities reduced clinical and domestic waste by an average of 15%, yielding cost savings and improved financial outcomes.



From a health services efficiency perspective, PLS, revenue, and SPR are pivotal in evaluating the performance of healthcare facilities. Enhanced waste management efficiency tends to shorten hospital stays, reduce operational costs, and improve service delivery. These improvements align with views of Williamson (1981) and Asgari et al. (2023) that organizations can reduce operational inefficiencies through integrated and trust-based systems.

Regarding SPR, the study revealed that collection and transportation costs positively and significantly influenced staffing efficiency, while disposal cost showed a positive but statistically non-significant relationship. This finding contrasts with Abah and Ohimain (2011), who documented poor HCW management practices in Nigerian hospitals, highlighting unsustainable waste segregation and treatment systems. Similarly, Ali et al. (2016) emphasized the role of reputational incentives and regulatory compliance in influencing hospital waste practices, underscoring that effective waste handling also boosts internal staff morale and productivity.

When analyzing the influence of waste costs on PLS, both collection and disposal costs were positively and significantly related to longer hospital stays, whereas transportation costs had a negative but non-significant effect. Paradis et al. (2009) emphasized that inefficient hospital processes, including poor waste handling, are linked to longer hospitalizations and adverse patient safety events. This suggests that while improved waste management can streamline patient turnover, inefficiencies in disposal systems may delay recovery and discharge. The study's findings partially support Clark (2018), who noted that implementing cost-effective waste strategies correlates with improved hospital performance in the U.S. healthcare system. However, the results diverge from Li et al. (2019), who argued that uncertainty in waste generation and disposal costs could hinder effective policy modeling in municipal solid waste management, a consideration that may also be relevant in developing countries like Nigeria.

Ultimately, the data suggest that an optimized balance between waste management expenditures and performance outcomes is crucial. This balance not only minimizes health and environmental risks but also contributes to resource efficiency and institutional sustainability. Effective waste handling practices must be context-sensitive, accounting for hospital layout, patient flow, and department-specific needs, to prevent complications, reduce resource wastage, and enhance care quality (World Health Organization, 2022). The findings align with the theoretical lens of the Theory of Waste Management (TWM), which advocates for



environmentally sound and health-protective waste practices. Waste management should be proactive, integrating reduction, reuse, and proper disposal strategies to conserve resources and protect human well-being (Hossain et al., 2023). However, this study observed that current practices still fall short of fully achieving these theoretical ideals, particularly in maximizing the environmental and operational returns of healthcare waste investments.

The findings revealed nuanced relationships. Specifically, CC and DC were negatively and significantly associated with patient length of stay, implying that improved investments in these components may contribute to reduced hospitalization duration. Conversely, these same cost elements exhibited positive and significant relationships with institutional revenue, indicating their strategic importance in driving financial performance. However, their influence on the staff-to-patient ratio was more complex: although theoretically consistent with efficiency expectations, only TC was statistically non-significant, suggesting variability in operational outcomes.

These results reinforce the necessity of integrated, efficient, and context-sensitive waste management systems in public health institutions. Given the hazardous nature of medical waste ineffective disposal practices not only jeopardize health outcomes but also contribute to environmental degradation (World Health Organization, 2022; Hossain et al., 2023). Furthermore, lack of staff awareness and inadequate training in waste handling has often transformed hospitals into potential vectors for disease transmission, particularly in developing countries like Nigeria (Adeleke et al., 2020).

5. Conclusion

This study demonstrates that healthcare waste management costs are a significant determinant of hospital performance in public healthcare facilities. Inefficiencies in waste collection, transportation, and disposal exert financial pressure on hospitals and negatively affect key performance indicators such as revenue generation, staff-to-patient ratios, and patient length of stay. By integrating both financial and non-financial performance measures, the study provides evidence that effective waste management is not only an environmental necessity but also a critical operational and economic concern. Strengthening waste management systems through targeted investments, improved segregation practices, and policy integration can enhance institutional efficiency and support the sustainable performance of public hospitals.



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