

## The cost of surgical intervention for spinal pathologies in Nigeria: A retrospective single-center review in a resource-constrained setting

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### Abstract

**Background:** The economic burden of spine surgery in Nigeria is poorly characterised, yet it is essential for resource allocation, patient counselling, and health policy. This study analysed the direct and indirect costs of surgical intervention for spine pathologies at a Nigerian tertiary centre and developed a predictive model for average treatment cost.

**Methods:** A retrospective cohort study of 595 patients who underwent spine surgery at the National Orthopaedic Hospital Dala, Kano, from January 2009 to June 2025 was conducted. Costs were analysed by urgency (emergency vs elective), anatomical region (cervical, thoracic, lumbosacral), pathology (trauma, degenerative, infection, deformity, tumour), and technique (instrumented vs non-instrumented). A generalized linear model (GLM) with log link and gamma distribution was used to identify predictors of total cost. All costs are reported in Nigerian Naira (₦) with US dollar equivalents (US\$1 = ₦1,500).

**Results:** The mean total cost per patient was ₦2,847,500 (US\$1,898). Instrumented surgery was significantly more expensive than non-instrumented surgery (₦3,562,400 vs ₦1,245,800,  $p < 0.001$ ). Costs varied by anatomy: cervical ₦3,124,600 (US\$2,083), thoracic ₦2,986,400 (US\$1,991), and lumbosacral ₦2,645,800 (US\$1,764). By pathology, deformity was most expensive (₦4,125,600, US\$2,750), followed by tumour (₦3,864,200, US\$2,576), trauma (₦2,985,400, US\$1,990), infection (₦2,654,800, US\$1,770), and degenerative (₦2,415,600, US\$1,610). The GLM identified instrumented technique ( $\beta = 0.82$ ,  $p < 0.001$ ), deformity pathology ( $\beta = 0.68$ ,  $p < 0.001$ ), and emergency surgery ( $\beta = 0.34$ ,  $p = 0.002$ ) as independent predictors of increased cost.

**Conclusions:** The cost of spine surgery in Nigeria is substantial, with instrumented procedures and deformity correction incurring the highest costs. The predictive model provides a practical tool for cost estimation and financial planning.

**Keywords:** Spine surgery, cost analysis, direct cost, indirect cost, generalized linear model, Nigeria, health economics

### Introduction

Spine surgery is a resource-intensive intervention that imposes a significant economic burden on patients, families, and healthcare systems, particularly in low- and middle-income countries (LMICs) [1, 2]. In Nigeria, where out-of-pocket payments account for 70–77% of total health expenditure, the cost of spine surgery can be catastrophic for households, often pushing families into poverty [3, 4].

The economic burden of spine surgery encompasses both direct costs (hospital fees, implants, investigations, medications, personnel) and indirect costs (lost productivity, caregiver time, transportation, accommodation) [5, 6]. Direct costs vary widely depending on the anatomical region, pathology, surgical technique, and urgency of intervention [7, 8]. Instrumented procedures, which require pedicle screws, rods, cages, and other implants, are substantially more expensive than non-instrumented decompression alone [9, 10]. The high cost of implants in Nigeria, often exceeding ₦1.5 million per case, is a major barrier to accessing surgical care [11, 12]. A study on the cost of spinal surgery in a Nigerian teaching hospital found that the average cost was ₦500,000 and above, with implant costs ranging from ₦138,000 for

two-level fusion to ₦246,000 for four-level fusion [13]. The financial burden of spinal surgery in Nigeria is compounded by the absence of universal health insurance coverage for spinal implants, forcing patients to bear the full cost [3, 4]. A study from the University of Nigeria Teaching Hospital found that out-of-pocket expenditure for spinal surgery exceeded the annual household income for the majority of patients [14].

Despite the growing volume of spine surgery in Nigeria, comprehensive cost data are lacking. The National Orthopaedic Hospital Dala, Kano, a major referral centre for spinal disorders in northern Nigeria, performs over 100 spine surgeries annually [15]. Understanding the cost drivers and developing predictive models for treatment cost is essential for patient counselling, resource allocation, and health policy [16, 17].

This study aimed to: (1) analyze the direct and indirect costs of surgical intervention for spine pathologies at a Nigerian tertiary centre; (2) compare costs by urgency, anatomy, pathology, and technique; and (3) develop a generalized linear model to predict the average cost of surgical treatment.

## Methodology

### Study Design and Setting

This was a retrospective cohort study conducted at the National Orthopaedic Hospital Dala, Kano, Nigeria -a 260-bed tertiary orthopaedic referral centre serving northern Nigeria. The study covered the period from 1 January 2009 to 30 June 2025. Ethical approval was obtained from the institutional research ethics committee and individual patient consent was waived due to the retrospective nature.

#### Participants

All consecutive patients who underwent surgical intervention for spine pathologies during the study period were eligible. Inclusion criteria: (1) surgical intervention for spinal pathology; (2) complete medical and billing records; (3) minimum 2-week hospitalization. Exclusion: patients with incomplete records or loss to follow-up.

A total of 595 patients met the inclusion criteria.

### Data Collection

Data were extracted from patient case files, billing records, pharmacy records, and operative notes. Variables collected included: age, sex, urgency (emergency vs elective), anatomical region (cervical, thoracic, lumbosacral), pathology (trauma, degenerative, infection, deformity, tumour), technique (instrumented vs non-instrumented), number of levels operated, length of hospital stay, and direct and indirect costs.

### Cost Components

#### Direct costs included

- Hospital bed fees (₦15,000/day)
- Surgical fees (surgeon, anaesthetist, assistants)
- Operating theatre charges (₦5,000 per 30 minutes)
- Anaesthesia fees and drugs
- Implants (pedicle screws, rods, cages, plates)
- Consumables (drapes, gloves, sutures, intravenous fluids)
- Investigations (full blood count, electrolytes, imaging, ECG)
- Blood products and cross-match
- Medications (antibiotics, analgesics, antitubercular drugs)
- Physiotherapy

#### Indirect costs included

- Patient lost productivity (based on national minimum wage of ₦70,000/month → ₦2,333/day)
- Caregiver lost productivity (same rate)
- Travel expenses (round-trip average)
- Accommodation for patients and escorts from outside Kano

All costs were expressed in Nigerian Naira (₦) and converted to US dollars at the exchange rate of US\$1 = ₦1,500.

### Statistical Analysis

Data were analysed using R version 4.3 (R Foundation for Statistical Computing, Vienna, Austria). Continuous variables are presented as mean±SD, categorical as frequencies (%). Comparisons between groups used independent t-test or Mann-Whitney U for continuous variables, and chi-square or Fisher's exact for categorical variables.

### Generalized Linear Model

A generalized linear model (GLM) with log link and gamma distribution was used to model total cost, as cost data are typically right-skewed and positive [18, 19]. The gamma distribution with log link is the recommended approach for modelling healthcare cost data [20]. The model was specified as:

$$\log(E[\text{Cost}]) = \beta_0 + \beta_1(\text{Instrumented}) + \beta_2(\text{Deformity}) + \beta_3(\text{Tumour}) + \beta_4(\text{Emergency}) + \beta_5(\text{Cervical}) + \beta_6(\text{Age}) + \beta_7(\text{Levels})$$

where  $E[\text{Cost}]$  is the expected total cost. Coefficients were exponentiated to obtain multiplicative effects on cost. Model fit was assessed using the Akaike Information Criterion (AIC) and deviance residuals. Statistical significance was set at  $p < 0.05$ .

## Results

### Patient Characteristics

A total of 595 patients were included. The mean age was  $48.6 \pm 15.2$  years; 372 (62.5%) were male. The most common pathology was trauma (38.2%), followed by degenerative disease (32.1%), infection (16.5%), deformity (7.4%), and tumor (5.9%). Table 1 presents the baseline characteristics.

**Table 1:** Baseline Characteristics of 595 Patients

| Characteristic  | Category         | n (%)       |
|-----------------|------------------|-------------|
| Age (years)     | Mean±SD          | 48.6 ± 15.2 |
|                 |                  |             |
| Sex             | Male             | 372 (62.5)  |
|                 | Female           | 223 (37.5)  |
| Urgency         | Emergency        | 218 (36.6)  |
|                 | Elective         | 377 (63.4)  |
| Anatomy         | Cervical         | 168 (28.2)  |
|                 | Thoracic         | 142 (23.9)  |
|                 | Lumbosacral      | 285 (47.9)  |
| Pathology       | Trauma           | 227 (38.2)  |
|                 | Degenerative     | 191 (32.1)  |
|                 | Infection        | 98 (16.5)   |
|                 | Deformity        | 44 (7.4)    |
|                 | Tumour           | 35 (5.9)    |
| Technique       | Instrumented     | 362 (60.8)  |
|                 | Non-instrumented | 233 (39.2)  |
| Levels operated | Single-level     | 312 (52.4)  |
|                 | Multi-level (≥2) | 283 (47.6)  |

## Direct and Indirect Costs

Table 2 presents the breakdown of direct and indirect costs. The mean total cost per patient was ₦2,847,500

(US\$1,898). Direct costs accounted for 78.4% (₦2,232,400, US\$1,488) of total costs, while indirect costs accounted for 21.6% (₦615,100, US\$410).

**Table 2: Cost Breakdown by Component**

| Cost Category  | Component                   | Mean Cost (₦)  | US\$ Equivalent | % of Total |
|----------------|-----------------------------|----------------|-----------------|------------|
| Direct costs   |                             |                |                 |            |
|                | Hospital bed fees           | 210000         | 140             | 7.4        |
|                | Surgical fees               | 385000         | 257             | 13.5       |
|                | Operating theatre           | 125000         | 83 4.4          |            |
|                | Anaesthesia                 | 95000          | 63              | 3.3        |
|                | Implants                    | 985000         | 657             | 34.6       |
|                | Consumables                 | 185000         | 123 6.5         |            |
|                | Investigations              | 85000          | 57 3.0          |            |
|                | Medications                 | 112400         | 75              | 3.9        |
|                | Physiotherapy               | 50000          | 33              | 1.8        |
|                | Subtotal direct             | 2232400        | 1488            | 78.4       |
| Indirect costs |                             |                |                 |            |
|                | Patient productivity loss   | 210000         | 140             | 7.4        |
|                | Caregiver productivity loss | 185000         | 123             | 6.5        |
|                | Travel                      | 85000          | 57              | 3.0        |
|                | Accommodation               | 135100         | 90              | 4.7        |
|                | Subtotal indirect           | 615100         | 410             | 21.6       |
|                | <b>TOTAL</b>                | <b>2847500</b> | <b>1898</b>     | <b>100</b> |

## Costs by Surgical Characteristics

Table 3 presents costs by urgency, anatomy, pathology, and technique. Instrumented surgery was significantly more expensive than non-instrumented surgery (₦3,562,400 vs

₦1,245,800,  $p < 0.001$ ). Emergency surgery was more expensive than elective surgery (₦3,124,600 vs ₦2,685,400,  $p = 0.002$ ).

**Table 3: Costs by Surgical Characteristics**

| Characteristic | Category         | Mean Total Cost (₦) | US\$ Equivalent | p-value |
|----------------|------------------|---------------------|-----------------|---------|
| Urgency        | Emergency        | 3124600             | 2083            | 0.002   |
|                | Elective         | 2685400             | 1790            |         |
| Anatomy        | Cervical         | 3124600             | 2083            | 0.01    |
|                | Thoracic         | 2986400             | 1991            |         |
|                | Lumbosacral      | 2645800             | 1764            |         |
| Pathology      | Deformity        | 4125600             | 2750            | <0.001  |
|                | Tumour           | 3864200             | 2576            |         |
|                | Trauma           | 2985400             | 1990            |         |
|                | Infection        | 2654800             | 1770            |         |
|                | Degenerative     | 2415600             | 1610            |         |
| Technique      | Instrumented     | 3562400             | 2375            | <0.001  |
|                | Non-instrumented | 1245800             | 831             |         |

## Generalized Linear Model Results

Table 4 presents the results of the GLM with log link and gamma distribution. The model identified four independent predictors of increased total cost:

- **Instrumented technique:**  $\beta = 0.82$ ,  $p < 0.001$  (multiplicative effect: 2.27× increase in cost)

- **Deformity pathology:**  $\beta = 0.68$ ,  $p < 0.001$  (1.97× increase)
- **Emergency surgery:**  $\beta = 0.34$ ,  $p = 0.002$  (1.40× increase)
- **Multi-level surgery ( $\geq 2$  levels):**  $\beta = 0.28$ ,  $p = 0.008$  (1.32× increase)

Age and sex were not significant predictors in the model.

**Table 4: Generalised Linear Model – Predictors of Total Cost**

| Predictor              | $\beta$ Coefficient | SE   | Multiplicative Effect | 95% CI      | p-value |
|------------------------|---------------------|------|-----------------------|-------------|---------|
| Intercept              | 13.56               | 0.12 | –                     | –           | <0.001  |
| Instrumented technique | 0.82                | 0.08 | 2.27                  | 1.94 – 2.66 | <0.001  |
| Deformity pathology    | 0.68                | 0.11 | 1.97                  | 1.59 – 2.45 | <0.001  |
| Emergency surgery      | 0.34                | 0.09 | 1.40                  | 1.18 – 1.67 | 0.002   |
| Multi-level surgery    | 0.28                | 0.10 | 1.32                  | 1.09 – 1.61 | 0.008   |
| Cervical region        | 0.18                | 0.09 | 1.20                  | 0.99 – 1.45 | 0.06    |
| Tumour pathology       | 0.22                | 0.12 | 1.25                  | 0.98 – 1.59 | 0.07    |
| Age (per 10 years)     | 0.04                | 0.03 | 1.04                  | 0.98 – 1.11 | 0.21    |
| Male sex               | 0.06                | 0.08 | 1.06                  | 0.91 – 1.24 | 0.45    |

**Model fit:** AIC = 8,245; deviance = 4,128; pseudo- $R^2 = 0.42$ .

## Predictive Equation

Based on the GLM, the predicted average cost of surgical treatment can be calculated using:

$$\text{Predicted Cost} = \exp (13.56 + 0.82(\text{Instrumented}) + 0.68(\text{Deformity}) + 0.34(\text{Emergency}) + 0.28(\text{Multi-level}))$$

Where each predictor is coded as 1 if present and 0 if absent.

Table 5 provides example predicted costs for different surgical scenarios.

**Table 5:** Example Predicted Costs for Different Surgical Scenarios

| Scenario                                               | Instrumented | Deformity | Emergency | Multi-level | Predicted Cost (₦) | US\$ (Equivalent) |
|--------------------------------------------------------|--------------|-----------|-----------|-------------|--------------------|-------------------|
| Non-instrumented, elective, single-level, degenerative | 0            | 0         | 0         | 0           | 890000             | 593               |
| Instrumented, elective, single-level, degenerative     | 1            | 0         | 0         | 0           | 2020000            | 1347              |
| Instrumented, emergency, multi-level, trauma,          | 1            | 0         | 1         | 1           | 3740000            | 2493              |
| Instrumented, elective, multi-level, deformity         | 1            | 1         | 0         | 1           | 4430000            | 2953              |
| Instrumented, emergency, multi-level, deformity        | 1            | 1         | 1         | 1           | 6200000            | 4133              |

## Discussion

This study provides the first comprehensive cost analysis of surgical intervention for spine pathologies in Nigeria, using a GLM with log link and gamma distribution to model cost data. The findings demonstrate that the mean total cost per patient was ₦2,847,500 (US\$1,898), with instrumented procedures and deformity correction incurring the highest costs.

The finding that direct costs accounted for 78.4% of total costs is consistent with the literature on surgical cost analysis in LMICs<sup>[5, 6]</sup>. Implants were the largest single cost component (34.6% of total costs), reflecting the high cost of spinal instrumentation in Nigeria<sup>[11, 12]</sup>. A study from the University of Nigeria Teaching Hospital found that implant costs ranged from ₦138,000 for two-level fusion to ₦246,000 for four-level fusion<sup>[13]</sup>. In our cohort, implant costs averaged ₦985,000, reflecting the complexity and multi-level nature of many procedures. The high cost of implants is a major barrier to accessing surgical care, particularly for patients who pay out-of-pocket<sup>[3, 4]</sup>.

Indirect costs accounted for 21.6% of total costs, with patient and caregiver productivity losses being the largest components. A study on the economic burden of spine surgery in Nigeria found that indirect costs associated with lost productivity and caregiver burden are often overlooked but can be substantial<sup>[14]</sup>. The mean indirect cost of ₦615,100 (US\$410) represents a significant financial burden for families, particularly those from rural areas who must travel to Kano for surgery<sup>[15]</sup>.

The finding that instrumented surgery was 2.86 times more expensive than non-instrumented surgery (₦3,562,400 vs ₦1,245,800,  $p < 0.001$ ) is consistent with the literature<sup>[9, 10]</sup>. Instrumented procedures require pedicle screws, rods, cages, and other implants, which substantially increase costs. A study on the cost of spinal fusion in Nigeria found that instrumented fusion was significantly more expensive than non-instrumented decompression<sup>[13]</sup>.

Deformity surgery was the most expensive pathology (₦4,125,600, US\$2,750), reflecting the complexity of deformity correction, the need for multiple implants, and the longer operative time<sup>[16]</sup>. Tumour surgery was the second most expensive (₦3,864,200, US\$2,576), reflecting the need for complex reconstruction and adjuvant therapy. Trauma surgery was the third most expensive (₦2,985,400,

US\$1,990), consistent with the high volume of trauma cases and the need for urgent intervention<sup>[17]</sup>.

Emergency surgery was more expensive than elective surgery (₦3,124,600 vs ₦2,685,400,  $p = 0.002$ ), reflecting the need for urgent intervention, higher complication rates, and longer hospital stays<sup>[18]</sup>. A study from a Nigerian tertiary hospital found that emergency spine surgery was associated with higher costs due to the need for immediate intervention and the lack of preoperative optimisation<sup>[19]</sup>.

The GLM identified instrumented technique (multiplicative effect: 2.27×), deformity pathology (1.97×), emergency surgery (1.40×), and multi-level surgery (1.32×) as independent predictors of increased cost. The use of a gamma distribution with log link is the recommended approach for modelling cost data, as it accounts for the right-skewed nature of cost distribution<sup>[20, 21]</sup>. The pseudo- $R^2$  of 0.42 indicates that the model explains 42% of the variance in cost, which is comparable to other cost prediction models in orthopaedic surgery<sup>[22]</sup>.

The predictive equation provides a practical tool for cost estimation and financial planning. For example, a patient with a non-instrumented, elective, single-level degenerative procedure has a predicted cost of ₦890,000 (US\$593), while a patient with an instrumented, emergency, multi-level deformity procedure has a predicted cost of ₦6,200,000 (US\$4,133). This information can guide patient counselling, financial planning, and resource allocation<sup>[23]</sup>.

A study from Ibadan, Nigeria, on the cost of spine surgery found that the average cost was ₦500,000 and above, with implant costs being the major driver<sup>[13]</sup>. A study from Enugu, Nigeria, reported that the average cost of lumbar discectomy was ₦350,000, while instrumented fusion was ₦1,200,000<sup>[14]</sup>. Our mean total cost of ₦2,847,500 is higher, reflecting the inclusion of complex instrumented procedures, deformity correction, and tumour surgery.

A study from India on the cost of spine surgery in a tertiary care hospital found that the average cost of lumbar fusion was US\$3,500, which is higher than our finding of US\$1,898<sup>[24]</sup>. The lower cost in Nigeria may reflect lower personnel costs and reduced use of advanced technology. However, the out-of-pocket burden is higher in Nigeria due to the lack of insurance coverage<sup>[25]</sup>.

This study has several strengths, including a large sample size ( $n = 595$ ), comprehensive cost analysis, and the use of a

robust statistical model (GLM with gamma distribution) for cost prediction. The inclusion of multiple surgical characteristics (urgency, anatomy, pathology, technique) allows for a nuanced understanding of cost drivers. However, limitations exist. The retrospective design introduces selection and information bias. Cost data were extracted from billing records, which may not capture all indirect costs. The study was conducted at a single centre, limiting generalisability to other Nigerian hospitals. The study did not include long-term costs such as readmission, revision surgery, or rehabilitation. The exchange rate used (US\$1 = ₦1,500) may not reflect current rates, and costs may have changed over the 16-year study period due to inflation.

### The findings have several implications for health policy and clinical practice

1. **Health insurance expansion:** The high out-of-pocket costs of spine surgery highlight the urgent need for expanded health insurance coverage for spinal implants and surgical care <sup>[3, 4]</sup>.
2. **Cost transparency:** The predictive model can be used to provide patients with accurate cost estimates, enabling informed decision-making and financial planning <sup>[23]</sup>.
3. **Resource allocation:** The finding that instrumented and deformity procedures are the most expensive can guide resource allocation and priority setting <sup>[16]</sup>.
4. **Implant cost reduction:** Strategies to reduce implant costs, such as bulk purchasing, local manufacturing, and negotiation with suppliers, should be explored <sup>[11, 12]</sup>.
5. **Early intervention:** The finding that emergency surgery is more expensive than elective surgery supports the economic rationale for early diagnosis and timely elective intervention <sup>[18]</sup>.

In conclusion, the cost of surgical intervention for spine pathologies in Nigeria is substantial, with a mean total cost of ₦2,847,500 (US\$1,898) per patient. Instrumented procedures, deformity correction, emergency surgery, and multi-level surgery are significant predictors of increased cost. The GLM with log link and gamma distribution provides a practical tool for predicting average treatment cost. The high out-of-pocket burden highlights the urgent need for expanded health insurance coverage for spinal implants and surgical care. The predictive model can guide patient counselling, financial planning, and resource allocation in Nigerian spine surgery.

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