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# Nigerian surgical outcomes – Report of a 7-day prospective cohort study and external validation of the African surgical outcomes study surgical risk calculator

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ABSTRACT

*Background:* Surgical outcomes study for individual nations remains important because of international differences in patterns of surgical disease. We aimed to contribute to data on post-operative complications, critical care admissions and mortality following elective surgery in Nigeria and also validate the African Surgical Outcomes Study (ASOS) surgical risk calculator in our adult patient cohort.

*Materials and methods:* We conducted a 7-day, national prospective observational cohort study in consented consecutive patients undergoing elective surgery with a planned overnight hospital stay following elective surgery during a seven-day study period. The outcome measures were in-hospital postoperative complications, critical care admissions and in-hospital mortality censored at 30 days. Also, we identified variables which significantly contributed to higher ASOS surgical risk score. External validation was performed using area under the receiver operating characteristic curve (ROC) for discrimination assessment and Hosmer–Lemeshow test for calibration.

*Results:* A total of 1,425 patients from 79 hospitals participated in the study. Postoperative complications occurred in 264(18.5%, 95% CI 16.6–20.6), 20(7.6%) of whom were admitted into the ICU and 16(6.0%) did not survive. Total ICU admission was 57 (4%), with mortality rate of 23.5% following planned admission and overall in-hospital death was 22(1.5%, 95% CI 0.9–2.2). All prognostic factors in the ASOS risk calculator were significantly associated with higher ASOS score and the scoring system showed moderate discrimination (0·73, 95% CI 0.62–0.83). Hosmer–Lemeshow $\chi 2$ test revealed scale was well calibrated in the validation cohort.

*Conclusion:* NiSOS validates the findings of ASOS and the ability of the ASOS surgical risk calculator to predict risk of developing severe postoperative complications and mortality. We identified failure-to-rescue as a problem in Nigeria. Furthermore, this study has provided policy makers with benchmarks that can be used to monitor programmes aimed at reducing the morbidity and mortality after elective surgery. We recommend the adoption of the ASOS surgical risk calculator as a tool for risk stratification preoperatively for elective surgery.

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## 1. Introduction

It has been reported that the poorest third of the world's population receive only 3.5% of the estimated 234 million major surgical operations undertaken worldwide [1]. This shows huge disparities in access to healthcare between low, middle and high-income countries and this disproportionately affects rural and marginal groups in low-income countries [1–3].

Also, it is widely known that complications after surgery are responsible for a large proportion of morbidity and mortality following surgery [2,3], with reports of early postoperative mortality varying between 2 and 4% [4]. The recently published African Surgical Outcomes Study (ASOS) revealed that mortality rate in Africa following elective surgery is double the global average [5].

Despite the findings from the ASOS and the International Surgical Outcomes Study (ISOS) [5,6], surgical outcomes data for individual nations remains important because of international differences in patterns of surgical disease, genetic backgrounds, and health care systems [6]. Furthermore, authors of the ASOS opined that the heterogeneous nature of surgical patients in Africa make individual country data mandatory.

Therefore, this national cohort study will help contribute to a better understanding of post-operative complications, critical care admissions and mortality following elective surgery in Nigeria. In addition, we hope to validate the ASOS Surgical Risk Calculator [7] (a tool developed to identify high-risk surgical patients in African hospitals) with data obtained from our patient cohorts. Once we understand the burden of morbidity and mortality associated with elective surgery, and are able to predict patients with poor outcome, resources will be better allocated with interventions targeted at factors important in improving patient outcomes. This study therefore, has important public health implications for Nigeria and will also provide a baseline for perioperative outcomes in the country.

## 2. Materials and Methods

### 2.1. Study design

We conducted a 7-day, national prospective observational cohort study. Approval of the National Health Research Ethics Committee of Nigeria was obtained (NHREC/01/01/2007-25/04/2018) and the study was registered on ID-NCT 03551912. We recruited all consented consecutive patients (adult and paediatric) admitted to participating centres undergoing elective surgery with a planned overnight hospital stay following surgery during the seven-day study period between 07:00hr of July 9 to 06:59hr of 16th July 2018. Patients undergoing emergency surgery, day-case surgery or radiological procedures were excluded.

The study ran in all the six geo-political zones and the Federal Capital Territory (FCT). Our initial plan was to recruit a minimum of three centres per state i.e. one federal, one state and one private health institution. However, the non-availability of intensive care facility, an inclusion criterion limited the number of institutions we eventually recruited. The following were coordinating centres for the study; The Regional coordinating centres were University College Hospital, Ibadan, Oyo State (South-West); University of Ilorin Teaching Hospital, Ilorin, Kwara State (North-Central); University of Nigeria Teaching Hospital, Enugu, Enugu State (South-East); Aminu Kano University Teaching Hospital, Kano, Kano State (North-West); University of Port-Harcourt Teaching Hospital, Port-Harcourt, Rivers State (South-South); University of Maiduguri Teaching Hospital, Maiduguri, Borno State (North- East); University of Abuja Teaching Hospital, Abuja (FCT). Following approval by the National Research Ethics Committee (NHREC), the principal investigator employed the collaboration established during the ISOS project to identify regional coordinators. The regional coordinators recommended coordinators for states in their geo-political zones. In addition, the social media platform of the Nigerian Society of Anaesthetist (NSA) was also employed to identify state co-ordinators. The state coordinators subsequently identified participating centres and local hospital coordinators within the state. Furthermore, separate social media platforms were created for regional coordinators, state and hospital coordinators for ease of conduct of the study. Patient recruitment preoperatively, and follow-up until discharge, were performed by local investigators. The study website provided further information about the study for investigators. The work has been reported in line with STROCSS criteria [8].

### 2.2. Data collection

Centre specific data collected included: Type of institution-Federal/State/Private; number of hospital beds; number of operating rooms; number of critical care beds, and facilities available in the Intensive Care Unit (ICU). An easy data set is important for the success of large observational studies, and this has been confirmed in the international outcomes study where data for 44 814 patients from 27 countries were collated [6], and similarly, the African study with data from twenty-five African countries [5]. We therefore adopted the core data variables and definitions of complications from the ASOS in order to achieve the study objectives and allow for comparison with similar studies. Complications were graded as mild, moderate, or severe [5]. Data for consecutive patients were collated using the paper case-record forms until hospital discharge and censored at 30 days following surgery for patients who remained in hospital. Data confidentiality was ensured before entry of the data unto Research Electronic Data Capture (RED Cap) [9].

### 2.3. Outcomes

The primary outcome measure was in-hospital postoperative complications. Secondary outcomes were admission to critical care, death following a postoperative complication (failure to rescue), and in-hospital mortality, all censored at 30 days following surgery.

### 2.4. Statistical analysis

We had no target sample size; our aim was to recruit every eligible patient in the participating centres during the study period. During the ISOS study, an average of 20 patients were recruited from each participating centre in Nigeria. Therefore, we expected approximately 25 patients per site i.e. a total of 2775 patients.

The authors of ASOS suggested that a sample of 3000 patients will provide a reliable mortality estimate of a 95% confidence interval spanning 1% and a sample of 1400 patients spanning 4%. The goal of the study was to present national outcomes figures and not to make comparison between states or type of institutions. The data describing the full cohort are presented in accordance with the STROBE guidelines for reporting cohort studies (Fig. 1) [10].

We described categorical variables as proportions and compared them using Fisher's exact test. Continuous variables were presented as mean (SD), or median (IQR) and compared using t-tests. Univariate analysis was performed to test factors associated with postoperative complications and in-hospital death. Generalised linear regression model was carried out to identify factors independently associated with the outcomes and to control for confounding risk factors. Factors were entered into the models based on their univariate significant relation with the outcomes. The result of logistic regression was reported as adjusted odds ratios (OR) with 95% confidence intervals.

The surgical risk score was calculated for each patient using the ASOS surgical risk calculator. A regression analysis of relevant ASOS surgical risk prognostic factors was performed aiming to identify significant variables which contributed to higher risk. The accuracy of the ASOS surgical risk calculator was then assessed in the validation cohort

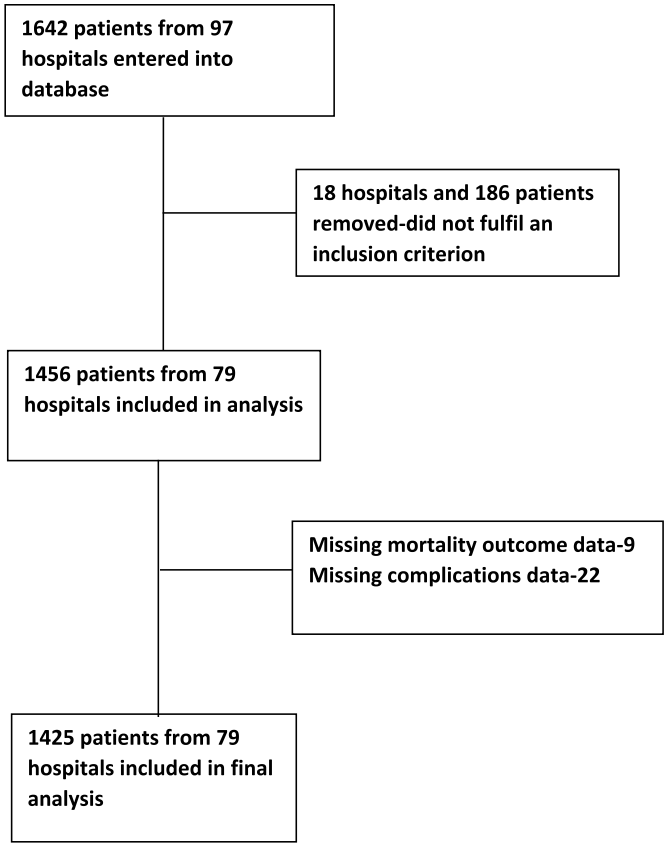


**Fig. 1.** Nigerian Surgical Outcomes Study-hospital and patient recruitment.

by calculating the area under the receiver operating characteristic curve (ROC) to measure discrimination. AUROC less than 0·7 is said to indicate poor performance, while 0·7–0·9 and > 0.9 show moderate performance and high performance respectively [11,12]. Hosmer–Lemeshow test was employed for calibration. A non-significant test result indicates that a model is well calibrated. Only data of patients ≥18 years were included in the validation cohort. Data analysis was carried out using the IBM® SPSS Statistics V22 (Chicago, Illinois).

## 3. Results

A total of 1,425 patients from 79 hospitals in every state of the country during the study week participated in the study, with the exception of Ekiti and Gombe where coordination was poor (Fig. 1). Data from 18 hospitals without facility for critical care were not included in the analysis. Table 1 showed the distribution of hospital types and facilities. The median number of patient/procedures per hospital during the study week was 21(range,1–67).

We had a total of 31(1.9%) patients with missing data for complications and in-hospital mortality and were therefore excluded from the data analysis. Other patients with missing data for other variables were included in the main analysis, the highest being for primary indication for surgery 33(2.0%). The mean age of the patients was 35.4(21.5) years with 301(21.2%) being under 18 years. About 90% of the patients had either ASA 1 or II physical status score, with the most common surgical severity being major surgery 781(55.0%). Surgical checklist was used in slightly over half of the patients 772(56.1%) with obstetrics as surgical procedure being the commonest 237(16.7%) and hypertension as the commonest comorbidity (Table 2).

A total of 264(18.5%, 95% CI 16.6–20.6) patients developed postoperative complications (Table 3). Among those with postoperative complications, 20(7.6%) were admitted into the ICU with most of the admission 14(77.8%) being immediately after surgery. Sixteen (6.0%) of those patients with complications did not survive (Table 4). The univariate associations with postoperative complications, mortality and the generalised linear model to determine independent risk factors are shown in the Appendix (Tables B1-B4). Patients with major surgery were twice as likely to develop postoperative complications when compared to patients with minor surgery (OR = 2.52, CI = 1.45–4.39). In addition, patients who had obstetrics, gynaecology and urology/kidney surgical procedures were found to be 65%, 58% and 48% respectively less likely to develop postoperative complications when compared to patients who had orthopaedic surgical procedure. Superficial surgical site infection and postoperative bleeding were the commonest complications (Table 3).

A total of 22(1.5%, 95% CI 0.9–2.2) patients died before hospital discharge with 12(54.5%) of them admitted to the ICU immediately after surgery (Table 4) and 2(0.12%) patients died within 24 h of surgery. Cardiovascular and pulmonary complications were associated with the highest mortality (Table 3). Patients who had hepato-biliary procedure were more likely to die than patients who had orthopaedic procedure (OR = 18.82, CI = 2.85–121.66) (Table B4). A total of 57 patients (4%) were admitted into the ICU, with 51(89.5%) admitted immediately after surgery. The mortality following planned admission was 23.5%.

Non-communicable disease was the commonest indication for surgery, however infective causes significantly led to more complications and mortality (Table 5). The comparison between ISOS, ASOS (elective patients) and NiSOS is shown in Table 6. Patients in the ASOS and NiSOS are younger compared to those in ISOS. Complication rate in NiSOS (18.5%) though similar to that obtained in ISOS (16.8%), the overall mortality is more than that in ISOS.

The calculated ASOS surgical risk scores for patients with or without severe complications were 9.55 ± 4.23 and 6.18 ± 3.57 (P = 0.001) and for the survivor and non-survivor, 6.18 ± 3.55 and 11.86 ± 4.17(P = 0.001) respectively. The regression analysis of relevant ASOS surgical risk prognostic factors in relation to the surgical risk score is presented in the Appendix (Table B5).

The tables showing reported mortality, postoperative complications, and critical admissions for the different types of hospitals, states and geo-political zones of the country are found in the Appendix (Tables B6-B8).

The ASOS surgical risk calculator demonstrated moderate discrimination with an AUROC of 0·73 (95% CI 0.62–0.83) (P < 0·001) (Fig. 2). The P-values for the Hosmer–Lemeshow $\chi 2$ test was 0.369, indicating that the model was well calibrated in the validation cohort.

**Table 1**
Hospital facilities and resources of participating centres.

| Resources | |
|---|---|
| **Hospital Type(n%)** | |
| Specialist/University Affiliated Hospital | 41(51.9) |
| General Hospital (Secondary care) | 38(48.1) |
| **Funding type of Institution(n%)** | |
| Federal government | 38(48.1) |
| State government | 33(41.8) |
| Private | 8(10.1) |
| **Hospital resources (median/25th/75th centile)** | |
| Hospital beds | 300(200–500) |
| Operating rooms | 6 (4–8) |
| ICU beds | 4 (2–6) |
| **ICU resources(n%)** | |
| Availability of Mechanical ventilation | 51(64.6) |
| Invasive Monitoring | 25(31.6) |
| Arterial blood gas analysis | 26(32.9) |

**Table 2**
Baseline patient characteristics.

| Characteristics | All patients n = 1425 | Patients with complications n = 264 | Patients without complications n = 1161 | Patients who survived n = 1403 | Patients who died n = 22 |
|---|---|---|---|---|---|
| **Age (years), mean (SD)** | 35.41 (21.51) | 35.35 (21.55) | 37.61 (20.41) | 35.38 (20.25) | 35.32 (20.16) |
| < 18 | 301/1422 (21.2%) | 54/263 (20.5%) | 247/1159 (21.3%) | 294/1399 (21.0%) | 7/22 (33.3%) |
| ≥18 | 1121/1422 (78.8%) | 209/263 (79.5%) | 912/1159 (78.7%) | 1105/1399 (79.0%) | 14/22 (66.7%) |
| **Sex(n/N%)** | | | | | |
| Male | 592/1422 (41.6%) | 119/264 (45.1%) | 473/1158 (40.8%) | 582/1400 (41.6%) | 10/22 (45.5%) |
| Female | 830/1422 (58.4%) | 145/264 (54.9%) | 685/1158 (59.2%) | 817/1400 (58.4%) | 12/22 (54.5%) |
| **Smoking(n/N%)** | | | | | |
| Yes | 55/1418 (3.9%) | 9/263 (3.4%) | 46/1155 (4.0%) | 55/1396 (3.9%) | 0/22 (0.0%) |
| **ASA Category(n/N%)** | | | | | |
| 1 | 604/1415 (42.7%) | 100/262 (38.2%) | 504/1153 (43.7%) | 600/1393 (43.1%) | 4/22 (18.2%) |
| 2 | 613/1415 (43.3%) | 108/262 (41.2%) | 505/1153 (43.8%) | 610/1393 (43.8%) | 3/22 (13.6%) |
| 3 | 163/1415 (11.5%) | 43/262 (16.4%) | 120/1153 (10.4%) | 154/1393 (11.1%) | 9/22 (40.9%) |
| 4 | 26/1415 (1.8%) | 9/262 (3.4%) | 17/1153 (1.5%) | 22/1393 (1.6%) | 4/22 (18.2%) |
| **Severity of surgery(n/N%)** | | | | | |
| Minor | 161/1420 (11.3%) | 23/262 (8.8%) | 138/1158 (11.9%) | 160/1399 (11.4%) | 1/20 (5.0%) |
| Intermediate | 478/1420 (33.7%) | 61/262 (23.3%) | 417/1158 (36.0%) | 473/1399 (33.8%) | 5/22 (22.7%) |
| Major | 781/1420 (55.0%) | 178/262 (67.9%) | 603/1158 (52.1%) | 766/1399 (54.8%) | 14/20 (70.0%) |
| **Surgical Checklist Used(n/N%)** | | | | | |
| Yes | 772/1425 (56.1%) | 503/264 (54.9%) | 269/1161 (58.5%) | 767/1384 (55.4%) | 13/22 (59.1%) |
| **Surgical Procedure(n/N%)** | | | | | |
| Orthopaedic | 223/1419 (15.7%) | 60/262 (22.2%) | 163/1157 (14.1%) | 221/1397 (15.8%) | 2/22 (9.1%) |
| Breast | 53/1419 (3.7%) | 13/262 (5.0%) | 40/1157 (3.5%) | 51/1397 (3.7%) | 2/22 (9.1%) |
| Obstetric | 237/1419 (16.7%) | 26/262 (9.9%) | 211/1157 (18.2%) | 236/1397 (16.9%) | 1/22 (4.5%) |
| Gynaecology | 225/1419 (15.9%) | 31/262 (11.8%) | 194/1157 (16.8%) | 225/1397 (16.1%) | 0/22 (0.0%) |
| Upper gastro-intestinal | 30/1419 (2.1%) | 5/262 (1.9%) | 25/1157 (2.2%) | 29/1397 (2.1%) | 1/22 (4.5%) |
| Lower gastro-intestinal | 117/1419 (8.2%) | 18/262 (6.9%) | 99/1157 (8.6%) | 115/1397 (8.2%) | 2/22 (9.1%) |
| Hepato-biliary | 19/1419 (1.3%) | 4/262 (1.5%) | 15/1157 (1.3%) | 15/1397 (1.1%) | 4/22 (18.2%) |
| Urology & Kidney | 182/1419 (12.8%) | 29/262 (11.1%) | 153/1157 (13.2%) | 182/1397 (13.0%) | 0/22 (0.0%) |
| Vascular | 2/1419 (0.1%) | 2/262 (0.8%) | 0/1157 (0.0%) | 2/1397 (0.1%) | 0/22 (0.0%) |
| Head & Neck | 171/1419 (12.1%) | 38/262 (14.5%) | 133/1157 (11.5%) | 170/1397 (12.2%) | 1/22 (4.5%) |
| Plastic | 92/1419 (6.5%) | 19/262 (7.3%) | 73/1157 (6.3%) | 91/1397 (6.5%) | 1/22 (4.5%) |
| Thoracic (lungs & Others) | 8/1419 (0.6%) | 3/262 (1.1%) | 5/1157 (0.4%) | 7/1397 (0.5%) | 1/22 (4.5%) |
| Thoracic (gut) | 17/1419 (1.2%) | 3/262 (1.1%) | 14/1157 (1.2%) | 16/1397 (1.1%) | 1/22 (4.5%) |
| Neurosurgery | 40/1419 (2.8%) | 9/262 (3.4%) | 31/1157 (2.7%) | 36/1397 (2.6%) | 4/22 (18.2%) |
| Cardiac surgery | 1/1419 (0.1%) | 1/262 (0.4%) | 0/1157 (0.0%) | 0/1397 (0.0%) | 1/22 (4.5%) |
| **Comorbidity(n/N%)** | | | | | |
| Coronary artery disease | 9/1425 (0.6%) | 6/264 (2.3%) | 3/1161 (0.3%) | 8/1403 (0.8%) | 1/22 (4.5%) |
| Congestive heart failure | 4/1425 (0.3%) | 0/264 (0.0%) | 4/1161 (0.3%) | 3/1403 (0.2%) | 1/22 (4.5%) |
| Diabetes mellitus | 55/1425 (3.9%) | 12/264 (4.5%) | 43/1161 (3.7%) | 52/1403 (3.7%) | 3/22 (13.6%) |
| Cirrhosis | 2/1425 (0.1%) | 0/264 (0.0%) | 2/1161 (0.2%) | 2/1403 (0.1%) | 0/22 (0.0%) |
| Metastatic cancer | 32/1425 (2.3%) | 11/264 (4.2%) | 21/1161 (1.8%) | 29/1403 (2.1%) | 3/22 (13.6%) |
| Hypertension | 232/1425 (16.7%) | 59/264 (22.3%) | 176/1161 (15.2%) | 233/1403 (16.6%) | 2/22 (9.1%) |
| Stroke | 3/1425 (0.2%) | 1/264 (0.4%) | 2/1161 (0.2%) | 3/1403 (0.2%) | 0/22 (0.0%) |
| COPD/Asthma | 12/1425 (0.9%) | 3/264 (1.1%) | 10/1161 (0.9%) | 13/1403 (0.9%) | 0/22 (0.0%) |
| HIV | 27/1425 (1.9%) | 3/264 (1.1%) | 24/1161 (2.1%) | 27/1403 (1.9%) | 0/22 (0.0%) |
| Chronic renal disease | 2/1425 (0.1%) | 1/264 (0.4%) | 1/1161 (0.1%) | 2/1403 (0.1%) | 0/22 (0.0%) |
| LRTI | 2/1425 (0.1%) | 0/264 (0.0%) | 2/1161 (0.2%) | 2/1403 (0.1%) | 0/22 (0.0%) |
| Congenital heart disease | 4/1425 (0.3%) | 2/264 (0.8%) | 3/1161 (0.3%) | 4/1403 (0.3%) | 1/22 (4.5%) |
| Obstructive sleep apnea | 17/1425 (1.2%) | 1/264 (0.4%) | 16/1161 (1.4%) | 17/1403 (1.2%) | 0/22 (0.0%) |
| URTI | 15/1425 (1.1%) | 1/264 (0.4%) | 14/1161 (1.4%) | 15/1403 (1.1%) | 0/22 (0.0%) |
| Others | 91/1425 (6.4%) | 17/264 (6.4%) | 74/1161 (6.4%) | 89/1403 (6.3%) | 2/22 (9.1%) |

Data are mean (SD) or n/N (%). Denominators vary with the completeness of the data. ASA-American Society of Anesthesiologists. URTI- Upper respiratory tract infection, LRTI- Lower respiratory tract infection, COPD -chronic obstructive pulmonary disease.

## 4. Discussion

### 4.1. Principal findings

In this study, postoperative complication rate was 18.5% (95% CI 16.6–20.6) in the patient cohort, of which the commonest was infective complications. One in 25 patients were admitted to the ICU, 1 in 17 died after a complication and in-hospital mortality was 1.5% (95% CI 0.9–2.2). All prognostic factors in the ASOS risk calculator were significantly associated with higher ASOS score in our patient cohort and the scoring system showed moderate performance for discriminating severe complications and in-hospital mortality (0·73, 95% CI 0.62–0.83) and was well calibrated in the validation cohort.

### 4.2. Strength and limitations

Studies from some institutions in Nigeria have reported complication and mortality rates following specific procedures, but we found none that provided a comprehensive dataset for surgical procedures and outcome at country level like the NiSOS. Another strength of this study is being the first to externally validate the ASOS surgical risk calculator in cohort of African surgical patients. Comparison of datasets between states, geo-political zones and the funding status of the institutions may not be directly possible because of the nature of the study, as well as the differences in health care systems at each level. Considering that only hospitals with a dedicated place as intensive care unit (ICU) are involved, some degree of selection bias may be present.

**Table 3**
Postoperative complications in the Nigerian Surgical Outcomes Study.

| | Number of Patients(n%) n = 1425 | Complication Severity(n/N%) | | | Number of deaths for all patients who developed complications(n/N %) |
|---|---|---|---|---|---|
| | | Mild | Moderate | Severe | |
| **Infectious complications** | | | | | |
| Superficial Surgical Site | 127(8.9) | 79/1421 (5.6%) | 41/1421 (2.9%) | 7/1421 (0.5%) | 3/127 (2.4%) |
| Deep surgical Site | 33(2.3) | 6/1419 (0.4%) | 16/1419 (1.1%) | 11/1419 (0.8%) | 1/33 (3.0%) |
| Body Cavity | 5(0.3) | 2/1417 (0.1%) | 2/1417 (0.1%) | 1/1417 (0.1%) | 0/5 (0.0%) |
| Pneumonia | 7(0.5) | 4/1418 (0.3%) | 3/1418 (0.2%) | 0/1418 (0.0%) | 1/7 (14.2%) |
| Urinary Tract | 5(0.3) | 3/1417 (0.2%) | 1/1417 (0.1%) | 1/1417 (0.1%) | 0/5 (0.0%) |
| Blood stream | 5(0.3) | 1/1415 (0.1%) | 2/1415 (0.1%) | 2/1415 (0.1%) | 2/5 (40.0%) |
| Total | **182(12.8)** | **95/1421(6.7%)** | **65/1421(4.6%)** | **22/1421(1.5%)** | **7/182(3.8%)** |
| **Cardiovascular complications** | | | | | |
| Myocardial Infarction | 3(0.2) | 3/1422 (0.2%) | 0/1422 (0.0%) | 0/1422 (0.0%) | 0/3 (0.0%) |
| Arrhythmia | 6(0.4) | 5/1420 (0.4%) | 1/1420 (0.1%) | 0/1420 (0.0%) | 2/6 (33.3%) |
| Pulmonary oedema | 6(0.4) | 3/1421 (0.2%) | 2/1421 (0.1%) | 1/1421 (0.1%) | 5/6 (83.3%) |
| Pulmonary embolism | 2(0.1) | 0/1420 (0.0%) | 0/1420 (0.0%) | 2/1420 (0.1%) | 2/2 (100.0%) |
| Stroke | 0(0) | 0/1419 (0.0%) | 0/1419 (0.0%) | 0/1419 (0.0%) | 0/0 (0.0%) |
| Cardiac Arrest | 10(0.7) | 0/1419 (0.1%) | 0/1419 (0.1%) | 10/1419 (0.6%) | 8/10 (80.0%) |
| Total | **27/1425(1.9)** | **11/1422(0.8%)** | **3/1422(0.2%)** | **13/1422(0.9%)** | **17/27(63.0%)** |
| **Other complications** | | | | | |
| Acute kidney injury | 8(0.6) | 4/1416 (0.3%) | 3/1416 (0.2%) | 1/1416 (0.1%) | 4/8 (50.0%) |
| Postoperative bleed | 104(7.3) | 77/1417 (5.4%) | 20/1417 (1.4%) | 7/1417 (0.5%) | 2/104 (1.9%) |
| ARDS | 2(0.1) | 0/1412 (0.0%) | 1/1412 (0.1%) | 1/1412 (0.1%) | 2/2 (100.0%) |
| Anastomotic breakdown | 8(0.6) | 2/1416 (0.1%) | 2/1416 (0.1%) | 4/1416 (0.3%) | 0/8 (0.0%) |
| Total | **122/1425(8.6)** | **83/1417(5.9%)** | **26/1417(1.8%)** | **12/1417(0.8%)** | **8/122(6.6%)** |

Denominators vary with the completeness of the data. Note - Some patients had more than one complication.

**Table 4**
Outcomes for patients according to planned admission to critical care immediately after surgery.

| Outcome | All patients n = 1425 | Patient admitted to critical care immediately after surgery n = 51 | Patient not admitted to critical care immediately after surgery n = 1374 |
|---|---|---|---|
| Mortality(n/N%) | 22/1425 (1.5%) | 12/51 (23.5%) | 10/1374 (0.7%) |
| Complication(s) (n/N%) | 264/1425 (18.5%) | 20/51 (39.2%) | 244/1374 (17.8%) |
| Critical care admission to treat complication(s) (n/N%) | 20/264 (7.6%) | 14/20 (77.8%) | 6/244 (2.5%) |
| Death following a complication (failure to rescue) (n/N%) | 16/264 (6.0%) | 10/20 (50.0%) | 6/244 (2.5%) |

**Table 5**
Association between primary indication for surgery and postoperative complications and in-hospital mortality.

| | All patients n = 1425 | Complication n = 264 | No complication n = 1144 | OR (95%CI) | p-Value | Died n = 22 | Survived n = 1403 | OR (95%CI) | p-Value |
|---|---|---|---|---|---|---|---|---|---|
| Non-communicable Disease | 1093 | 174(65.9%) | 919/1144 (80.3%) | Ref | NA | 15/22 (68.2%) | 1078/1403 (78.3%) | Ref | NA |
| Infective | 84 | 23 (8.7%) | 61/1144 (5.3%) | 1.99 (1.20–3.30) | 0.00** | 4/22 (18.2%) | 80/1403 (5.8%) | 3.59 (1.17–11.08) | 0.03* |
| Traumatic | 222 | 58 (22.0%) | 164/1144 (14.3%) | 1.87 (1.33–2.63) | 0.00** | 3/22 (13.6%) | 219/1403 (15.9%) | 0.98 (0.28–3.43) | 0.98 |

Data presented as n% or n/N (%). NA- Not applicable; **: $p > 0.001$; *: $p < 0.05$.

Also, there appears to be a selection bias in favour of federally funded institutions and university affiliated hospitals, this may affect generalisability across Nigeria. Though two states (Gombe and Ekiti) were not included in this study, it is unlikely that data from these states will affect our results significantly. In view of national differences with regards to surgical population, more studies will be required to further provide further external validation of the ASOS surgical risk calculator.

**Table 6**
Comparison between elective patients in ISOS, ASOS and NiSOS.

| Variable | ISOS | ASOS | NiSOS |
|---|---|---|---|
| | n = 44814 | n = 4874 | n = 1425 |
| Age, (Mean) SD | 55.3(17.1) | 38.5(16.1) | 35.4(21.5) |
| ASA 1(n%) | 11227(25.1) | 1737 (44·9) | 604(42.4) |
| Minor surgery(n%) | 8411(18.8) | 1140 (29·5) | 161(11.3%) |
| Mortality(n%) | 207(0.5) | 48(1·0) | 22(1.5%) |
| Complications(n%) | 7508(16·8) | 624(13·4) | 264(18.5%) |
| Mortality after complications(n%) | 207(2·8) | 30(4.8) | 16(6.0%) |

### 4.3. Our results in relation to existing literature

The development of a postoperative complication indicates an important change in the recovery of a patient. It often leads to an increased risk of reoperation, prolonged length of stay, decline in

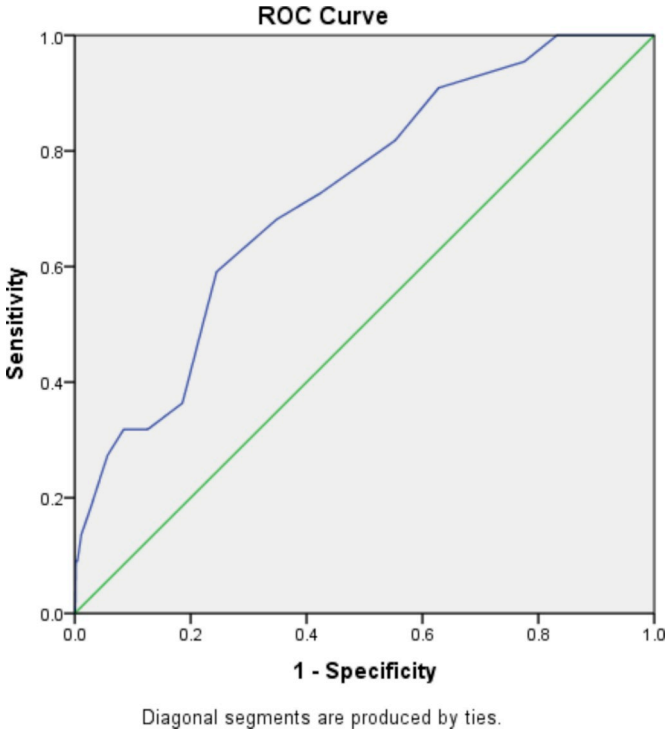


**Fig. 2.** Area under the ROC for ASOS calculator.

disposition and increased mortality [13]. It is therefore not surprising to have 6% rate (failure-to-rescue) in those with complications compared to 0.5% in those without. This is comparable to figures from the ASOS, though with a lower failure-to-rescue of 4.8%. Failure-to-rescue has been used in high-income countries to provide a useful metric of the quality of postoperative care for surgical patients [14,15]. Importantly, the much lower failure-to-rescue of 2.8% obtained in the ISOS and the fact that none of those patients without postoperative complications died in the ISOS compared to 0.5% and 0.4% in the NiSOS and ASOS respectively may be explained by better postoperative care available in HIC that made up 70% of countries involved in the study. This however calls for better funding and more research to improve this aspect of care in African countries.

Postoperative complications can vary with surgical procedures. In this review, complications varied from 0.4 to 22.2% following closed cardiac and orthopaedic surgery respectively. Higher complication rates had been reported especially following vascular, upper and lower GI procedures [16,17]. The high mortality rate following complications like blood stream infection, acute kidney injury, pulmonary oedema, pulmonary embolism and ARDS compared to that obtained in similar outcomes study [5,6] question the quality of perioperative care available in Nigeria.

The rate of unplanned ICU admission had long been suggested as a measure of patient safety and was associated with excess mortality in several types of surgical procedures (odds ratio, 3.89; 95% CI, 2.14–7.04) [18]. The findings from our study seem to confirm this statement as 10% of ICU admission in our study was unplanned and mortality in this group was 100%, compared to a mortality of 23.5% in those with planned admission. The mortality rate of 23.5% in those with planned admission is much higher than that obtained in the ASOS and ISOS. It is possible that the larger percentage of patients in the major surgery category in the NiSOS cohort compared to a third in the other two studies played a role. Nonetheless, failure to rescue any of the patients in the unplanned ICU admission group may reveal late identification of physiological deterioration and/or indirectly reveal the poor level of critical care services. This is evidenced by having only a third of the participating hospitals with facility for arterial blood gas analysis and invasive monitoring and two-third able to provide mechanical ventilatory support in the ICU. Optimum critical care beds and trained personnel for the ICU are two important determinants of improved critical care services [19]. Unfortunately, most countries in sub-Saharan Africa including Nigeria have problems with these [20]. The low level of ICU admission in our study (4%) compared to 10.5% in the ISOS probably reflects these challenges. Uganda as a whole has only one ICU bed for every one million Ugandans or 0.1 ICU beds/100,000 [21] and South Africa, 8.9/100,000 [22]. A crude rate for Nigeria from this study is approximately 0.2/100,000.i.e 2 beds/million (Total ICU beds recorded were 385). Most European countries have rates above 4/100,000 i.e 40 beds/million [23]. There is an urgent need to increase critical care capacity in Nigeria, both within and outside of ICUs.

Despite the recommendation of the Lancet Commission on Global Surgery on the use of perioperative mortality rate (POMR) as one of six key indicators to measure the strength of a country's surgical system [24], not much is being done by sub-Saharan African countries to provide insight into the pattern of postoperative mortality associated with surgical procedures. NiSOS, like South African Surgical Outcomes Study [25] has provided measurable outcomes for Nigeria that can be easily compared with that of other nations to assess surgical care.

Postoperative mortality in low and middle-income settings is reported to be nine-fold higher than that in high-income countries (3.44 vs 0.38 per 100 admissions, respectively) [26] often because of less efficient mechanisms to monitor care at all levels. The in-hospital mortality rate obtained for the NiSOS is similar to that obtained in the study by Sileshi et al. [27] where perioperative data of 8,419 cases were collated over 20 months in a major hospital in Kenya and consistent with that obtained in the ASOS. Similarly, one-year cohort study on surgical outcomes in eastern Uganda reported a 30-day POMR of 1.0% for elective surgery [28], though fewer surgical procedures were included. However, postoperative mortality in low- and middle-income countries is said to range from 3.44 to 6.00% [26,29–31]. The assertion by the authors of ASOS about the possibility of the drivers of perioperative death across African countries being consistent may be true after all as higher ASA class, Hepatobiliary and Neurosurgery are similarly predictors of mortality in the NiSOS and Kenyan study [27]. Though our study was not designed to compare outcomes among hospital types, states or geo-political zones, in-hospital mortality appears lower in federally funded institutions (1.3%) compared to that of states (2.1%) and private institutions (2.0%).

It has been shown that the use of simple bedside tools can accurately predict patients who might experience prolonged lengths of stay and interventions as a result of complications [32]. Therefore, the validation of the ASOS surgical risk calculator in this study should lead to improved patient selection and resource allocation in Africa for patients coming for elective surgery.

### 4.4. Clinical implications

There is a major need for the prevention of severe postoperative complications which often lead to death. In addition, the high failure-to-rescue rate suggests the need for better postoperative surveillance (may include the use of early warning signs) and improved critical care capacity. We have provided national surgical outcome baselines for Nigeria, the first objective of the National Surgical, Obstetrics and Anaesthesia (NSOA) plan, a World Health Organisation strategy to improve national surgical systems. This will allow tracking of surgical systems in Nigeria, setting of national health targets and constructive comparison of outcomes between countries. The ASOS surgical risk calculator can also be incorporated into the NSOA plan to improve patient selection and human resource allocation.

### 4.5. Unanswered questions and future research

Sufficiently powered and possibly longitudinal studies are required

to determine the true incidences of postoperative complications and in-hospital mortality at the different levels of care and states in Nigeria. Further studies should also seek to determine the contribution of anaesthesia to perioperative morbidity and mortality. The validation of the ASOS surgical risk calculator should make it possible to identify a patient cohort who can be subjected to preoperative improvement measures, though further studies are required to validate the scoring system in more countries in Africa.

## 5. Conclusion

NiSOS validates the findings of ASOS and the ability of the ASOS surgical risk calculator to predict risk of developing severe postoperative complications and mortality. We identified failure-to-rescue as a problem in Nigeria. The Nigerian Surgical Outcomes Study has provided policy makers with benchmarks that can be used to monitor programmes aimed at reducing the morbidity and mortality after elective surgery. We recommend the adoption of the ASOS surgical risk calculator as a tool for risk stratification preoperatively for elective surgery.

## Ethical approval

The study was approved by the National Health Research Committee (reference number).

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## Author contribution

Study design: All authors.
Study coordination: BO, TO, OO, OA, FA, OB, AM, AN.
Data analysis: BBO.
Interpretation of data: All authors.
Writing: All authors.

## Registration unique number

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## Guarantor

BO is the principal investigator and guarantor in this research.

## Data statement

The authors are yet to receive ethical permission to share data.

## Provenance and peer review

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## Data statement

The authors are yet to receive ethical permission to share data.

## CRediT authorship contribution statement

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## Conflicts of interest

None.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijsu.2019.06.003.

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