**RISK FACTORS FOR READMISSION AND LENGTH OF INPATIENT STAY IN RURAL GHANA FOLLOWING EXPLORATORY LAPAROTOMY**

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**ABSTRACT**

**Background:** Increased inpatient length of stay (LOS) and readmission represent significant economic burden on patients and families faced with surgical disease in low-middle income countries given limited surgical access, infrastructure, and variable insurance status.

**Study Aim:**Identify risk factors for readmission and inpatient LOS in postoperative care in the Eastern Regional Hospital, Ghana.

**Study Design:**Retrospective case series.

**Setting:** Eastern Regional Hospital, Koforidua, Ghana.

**Methods:** Data for exploratory laparotomy procedures were obtained from surgical case logs collected at the regional referral hospital in Koforidua, Eastern Region, Ghana from July 2017 to June 2018. This information was combined with the hospital electronic medical records to collect demographic data, laboratory values, and outcomes. Multivariable analyses were used to model LOS and readmission.

**Results:** The study included 346 exploratory laparotomy procedures (286 adult, 60 pediatric) for various surgical diseases. The overall 30-day readmission rate was 9.2%. Average LOS was 12.0±20.4 days for readmitted patients and 6.7±5.5 days for patients without readmission. Readmitted patients were more likely to have had preoperative anemia (p=0.009), surgical site infection (*P*=0.001), or a re-laparotomy (p=0.005). Preoperative anemia (OR=3.5 [95% CI 1.54-7.96], p=0.003) and surgical site infection (OR=3.68 [95% CI 1.36-10.00], p=0.011) were associated with increased odds of readmission. Preoperative anemia was also associated with about 3.0 additional inpatient days (p=0.001).

**Conclusions:** Preoperative anemia and surgical site infections represent risk factors for readmission in rural Ghana. Anemia is also associated with longer LOS. Future interventions aimed at treating anemia and preventing surgical site infections may reduce some of the post-operative burden placed on patients and their families.

**Key words:** readmission; length of stay; exploratory laparotomy, surgical burden of disease

**Introduction**

The unmet burden of surgical disease in low- and middle-income countries (LMICs) has been well established as a critical challenge.1 In sub-Saharan Africa, the cost of this surgical burden has been estimated to be 38 disability adjusted life years (DALYS) lost per population of 1,000.2 Barriers to surgical care related to social behaviors and norms, healthcare workforce scarcity, or community infrastructure can impact surgical outcomes and increase costs. Furthermore, these barriers are likely to impact patients, their families, and healthcare institutions.3

In Ghana, much of the literature on surgical outcomes and barriers to improved surgical care have come from tertiary hospitals in relatively population dense areas.4-7 It has not been well established whether these reported patient outcomes appropriately represent the surgical outcomes of referral centers that serve more rural populations.

The Eastern Regional Hospital (ERH), located in Koforidua and staffed by a single general surgeon for all emergent general surgery, serves as the surgical referral center for the 2.6 million people (56% of whom live in a rural setting) in Eastern Region, Ghana.8 The average monthly household income for this population is roughly $152.9 On average, patients of this region travel 98 km to reach the referral center.10 Two short-term outcomes with profound impact on this population and the surgical infrastructure are readmission and length of stay, especially for those patients undergoing major surgical operations.

In an effort to identify areas for future quality improvement, we sought to determine the rates and risk factors for 30-day readmission, as well as the incidence and risk factors of increasing length of stay (LOS) for patients undergoing exploratory laparotomy at ERH.

**Methods**

**Data sources**

Patient records from the electronic medical record (EMR) in conjunction with the surgical logbook at ERH were retrospectively reviewed to obtain data for this study. The electronic medical record currently used at ERH is the Health Administration Management System or HAMS (Infotech Dot Net Systems LTD). The surgical logbook is a separate record kept near the operative theatre and maintained by the staff. This record is overseen by the staff surgeon and contains a record of all operative procedures performed. A unique patient identification number recorded in both the EMR and the logbook allowed for the records to be appropriately combined.

Data was obtained only after the study was approved by the institutional review board at Penn State Health as well as the by the ERH leadership which included the hospital medical directors and members of the ERH quality committee.

**Population**

All records of patients who underwent exploratory laparotomy between July 1, 2017 and June 30, 2018 at ERH were considered for the study. These records included those of both adults and children and reported on operations supervised by a single general surgeon. This surgeon was assisted by a theatre nurse, certified registered nurse anesthetist, and rotating medical/house officer assistant.Exploratory laparotomy was defined as an open abdominal operation via a midline incision in all emergent and urgent settings. Patients with planned open abdominal operations, such as stoma reversals, were not included in the study. Additionally, appendectomy operations that were performed through a non-midline incision were excluded. Disagreement between the EMR and the surgical logbook was the primary reason for exclusion from the study. Records were also excluded if the operation was not clearly defined as an exploratory laparotomy.

**Outcomes**

There were two primary outcomes for the study. First, rates of readmission were calculated and risk factors for these readmissions were identified. Readmission was defined as any discharge and return admission to ERH for any reason within 30 days. Second, average inpatient length of stay for several disease processes was calculated and risk factors for increased length of stay were identified. Inpatient length of stay included the period before and after an exploratory laparotomy that a patient was admitted to ERH.

**Covariates**

The records included in the study contained patient information that allowed for evaluation of both demographic and clinical covariates. Demographic covariates included age, sex, marital status, occupation, and insurance status. Clinical covariates analyzed categorically included hemoglobin levels prior to operation, white blood cell (WBC) counts per mcL of blood prior to operation, and diagnosis. Other clinical covariates analyzed in binary fashion included whether the operation was associated with a postoperative surgical site infection, bowel resection, malignancy, or was a re-laparotomy.

For our analysis, re-laparotomy was used as a descriptive covariate to indicate that the given operation was a repeat operation for ongoing management of an index disease process. It should be noted that this is more specific than indicating anyone with a history of exploratory laparotomy for any reason.

Surgical site infections were recorded only if the EMR specifically indicated a surgical site infection. No additional retrospective interpretation of physical exam findings or laboratory values was used to determine surgical site infections. Anemia was defined as a hemoglobin less than 12 g/dl based on suggested guidelines from the World Health Organization (WHO) applied to the most common patients in this study.11

The authors convened to determine covariates to include in multivariable models based on those which were most likely believed to influence the outcomes of readmission and length of stay prior to beginning the analysis. Despite the limited sample size of readmissions and the risk of possibly overfitting the logistic regression model, we maintained all original covariates, even those that were not statistically significant in the model, for the purpose of avoiding post-test estimation bias.

All demographic and laboratory data points were obtained on index admission for the surgical procedure.

**Statistical analysis**

Patients included in the study were stratified by readmission and baseline characteristics and then compared between the cohorts using chi-squared tests. Logistic regression modeling was used to identify predictors of readmission and account for covariate confounding. Covariates used in the model included: age, sex, occupation, insurance status, hemoglobin level, re-laparotomy, surgical site infection, bowel resection, and malignancy. The appropriateness of the model was assessed with the area under the receiver operating characteristic (ROC). Covariates were assessed for goodness of fit with the Hosmer Lemeshow statistic. Additionally, a sensitivity analysis was performed by fitting models with each covariate separately as suggested by our statistician and comparing results to the fully specified multivariable model.

Predictors of length of stay were identified using linear regression modeling. Covariates similar to those of the logistic regression model were included in linear regression modeling with the addition of a bowel obstruction covariate. The coefficient of determination (R2) was calculated to determine goodness of fit. The software used to perform the statistical analysis was STATA (version 10.1, StataCorp, College Station, TX, USA). Statistical significance was defined by p -value < 0.05.

**Results**

The study included 346 patients (286 adult, 60 pediatric) who underwent exploratory laparotomy after exclusion of 12 patients with contradicting data in the EMR and surgeon’s logbook. Thirty-two patients were readmitted to ERH within 30 days of discharge for an overall readmission rate of 9.2%. The average age of patients who were not readmitted was 40.0 years (range 3 months – 98 years, standard deviation [SD] 21.8 years) and the average age of patients who were readmitted was 40.3 years (range 2 years – 77 years, SD 22.0 years). Characteristics of patients, stratified by readmission status, are shown in Table 1. Patients who were readmitted were more commonly anemic prior to surgery (p = 0.009) when compared to those who were not readmitted. Readmitted patients were more commonly associated with an operation that was a re-laparotomy (p = 0.005); surgical site infections were also more common in this cohort (p = 0.001). Patients who were readmitted had longer LOS prior to initial discharge compared to those who were not readmitted (12.0±20.4 days vs 6.7±5.5 days, p= 0.024).

Modeling of readmission resulted in identification of protective and predictive risk factors in Table 2. The area under the ROC curve was 0.766. The Hosmer Lemeshow goodness of fit analysis did not give any indication of poor fit (p= 0.9476). Female sex was the only covariate that was associated with lower odds of readmission (p= 0.030). Patients who had National Health Insurance (NHI; p= 0.049), preoperative anemia (p = 0.003), and SSI (p= 0.001) had greater odds of 30-day readmission. Univariate regressions for each covariate produced similar results to those obtained in the multivariable model.

Analysis of LOS revealed the average LOS for all exploratory laparotomy operations included in the study was 7.2 days. Figure 1 depicts the average LOS for the most common surgical disease processes. The shortest average LOS of stay was associated with appendicitis (4.5 days) and the longest average LOS was associated with typhoid ileitis (11.3 days).

Modeling of LOS is shown in Table 3. Unsurprisingly, after controlling for covariates, bowel obstruction (additional 2.77 days, p = 0.008) andre-laparotomy (additional 8.86 days, p< 0.001) were associated with longer LOS. Notably, preoperative anemia was also associated with longer LOS (additional 2.98, p= 0.001). The coefficient of determination for the model was 0.19.

**Discussion**

Increased readmissions and length of stay represent short-term surgical outcomes that can have profound effect on an already overburdened surgical infrastructure. For patients, increased time in the hospital represents higher healthcare costs and time away from earning wages; however, premature discharge would likely increase readmission rates due to inadequate management and/or inadequate preparation to arrange for follow-up and outpatient wound care. Furthermore, for those who need to return to the hospital from significant distances, transportation may prove difficult. Ghana currently has a developing ambulance service that had 199 vehicles for the entire country in 2014.12 Whether or not the rural population has appropriate access to these services deserves further investigation. In general, it is likely that the burden of transportation falls on the patient’s family. For family members, transporting loved ones results in lost time and wages often required to support other family members. It is clear how readmissions and increased length of stay can cause economic hardships, even catastrophic ones. The Lancet Commission recognized the importance of these catastrophic expenditures and categorized them as a primary indicator for global surgery.1 The impact of readmission and increased length of stay on catastrophic expenditures was beyond the scope of this initial study but surely deserves further investigation.

Consideration of the impact of readmission and increased inpatient length of stay on hospital infrastructure is critical. Readmissions and patients staying for extended lengths of time occupy limited hospital beds that may otherwise be filled by patients with the aforementioned, unmet surgical disease. The extra workload on nursing staff and surgeons also deserves mention. For LMICs, the surgical provider density has been estimated between 0.13 and 1.57 general surgeons per 100,000 people.13,14 Often these calculations include a number of specialist surgeons. The experience in the Eastern Regional Hospital, Ghana suggests that these estimations are likely overinflated for surgeons willing to perform necessary emergency laparotomies.

Our study found an overall readmission rate of about 9.2% following exploratory laparotomy. Unfortunately, there were no studies with comparative results in the literature for other areas of rural Ghana or sub-Saharan Africa. The literature in other LMICs is similarly limited with one retrospective case series reporting a readmission rate of 7.8%.15 This study identified several fascinating characteristics associated with patients who were readmitted compared to those who were not. Most notably, they more commonly had pre-existing anemia and had significantly higher associations with surgical site infections post operatively. Our statistical models corroborated the importance of these findings. Pre-operative anemia and post-operative surgical site infection were associated with significantly higher odds of readmission.

Surgical site infections in sub-Saharan Africa were reported at a rate of nearly 15% in a meta-analysis including studies from several countries. General surgical procedures accounted for a predominance of the cases.16 This aligned well with the slightly less than 10% rate of SSIs identified in this study. In the United States, SSIs are strongly correlated with readmissions.17 While this could also be the case in sub-Saharan Africa, there is a dearth of literature regarding the impact of SSIs on readmissions in the region. However, there are several studies that have begun to identify risk factors for SSI, which include wound class, disease pathology, hemoglobin levels, ASA score, and procedure length.16,18 A better understanding of these predictors could prove useful in implementing programs to improve readmission rates.

Another, perhaps surprising, predictor of readmissions was NHI coverage. We believe that this suggests that some uninsured patients who would benefit from readmission are not returning possibly due to the previously described barriers. Overall, the rate of individuals in our study who were not insured was not inconsequential at 40%. In 2009 the predicted enrollment rate of all Ghanaians was 55% and it appears that there has been limited progress in improving overall enrollment. While the premium cost of $5 per person per year does not seem overburdensome, it may well be in the Eastern Region of Ghana which has a poverty rate of 45%.9

In regard to LOS, readmitted patients had, on average, longer initial hospitalizations likely suggesting that readmissions are not due to premature discharge. The most notable predictor of LOS in our models was pre-operative anemia. Obstruction and re-laparotomy were also significant in predicting LOS. This was unsurprising given that these covariates were included to account for the confounding of increased LOS in initial management of obstructive disease and increased LOS associated with a re-laparotomy that had already been hospitalized for some time.

The findings in our study support an increasing body of evidence that pre-operative anemia may have an insidious impact on the surgical burden in sub-Saharan Africa. In one study of nearly 900 patients from the Central Region of Ghana, over 50% had pre-operative anemia which increased the odds of length of stay.19 In another study of over 2,000 patients compiled throughout sub-Saharan Africa, 38% presented with pre-operative anemia which resulted in increased odds of SSI, readmission, and complications.20 The underlying cause or causes of this anemia are unclear but a better understanding of the drivers of this process merits better investigation. Specifically, sickle cell disease which has a prevalence of 1.6% in the Ghanaian population and malaria which occurs with a frequency of 75 cases per 1000 people, deserve to be included in this investigation.21 Additionally, anemia may well represent a surrogate for malnutrition, unrecognized comorbidities, or lower socioeconomic status that could be the true drivers of the prevalent anemia.

There are a number of limitations in our analysis that deserve mention. First, the retrospective nature of the study in conjunction with the limitations of the EMR limited our ability to account for important variables such as comorbidities, previous treatments, follow-up care, and medication use. Going forward we plan to use this analysis as a springboard for identifying other surgical datapoints that should regularly be recorded. Second, the overall power of the study due to sample size was limited. In turn, the relatively small sample size of readmitted patients likely resulted in some overfitting of the multivariable regression model as possibly suggested by the adjusted R-squared calculation. To account for this, we performed univariate regressions for each covariate and the similar results gave us confidence in the findings of the multivariable model. Third, missing data in regards to patient hemoglobin and white blood cell counts likely resulted in some bias. Fourth, our study would not have captured any patients readmitted to other facilities. Fifth, an inability to differentiate preoperative and postoperative LOS means that it is possible that prolonged LOS was partially driven by inpatient stay prior to operation. Finally, overall reporting of surgical outcomes is likely underestimated due to the patient burdens of returning routinely for follow-up.

In conclusion, we have identified several areas of interest for future investigation and possible quality improvement. Efforts to improve the rates of SSIs may help reduce readmissions and improved enrollment in NHI may encourage the uninsured to seek out more appropriate post-operative care. Additionally, pre-operative anemia may well represent a target for future interventions that could ultimately reduce readmissions and decrease LOS, freeing the limited providers to continue to address the burden of uncovered surgical operations and reducing the surgical burden of disease.

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| **Table 1.** Baseline patient characteristics stratified by 30-day readmission following surgery | | | | |
| Variable | All Patients  (*n* = 346) | No Readmission  (*n* = 314) | Readmission  (*n* = 32) | *P* -value |
| Age, mean, years (SD) | 40.0 (21.8) | 40.0 (21.8) | 40.3 (22.0) | 0.941 |
| Sex |  |  |  | 0.202 |
| Male | 224 (64.7%) | 200 (63.7%) | 24 (75.0%) |  |
| Female | 122 (35.3%) | 114 (36.3%) | 8 (25.0%) |  |
| Marital status |  |  |  | 0.604 |
| Single | 133 (38.4%) | 119 (37.9%) | 14 (43.8%) |  |
| Married | 170 (49.1%) | 155 (49.4%) | 15 (46.9%) |  |
| Widowed | 23 (6.6%) | 20 (6.4%) | 3 (9.4%) |  |
| Divorced | 12 (3.5%) | 12 (3.8%) | 0 (0.0%) |  |
| Unknown | 8 (2.3%) | 8 (2.5%) | 0 (0.0%) |  |
| Occupation |  |  |  | 0.962 |
| Laborer | 143 (41.3%) | 130 (41.4%) | 13 (40.6%) |  |
| Professional | 25 (7.2%) | 23 (7.3%) | 2 (6.3%) |  |
| Student | 82 (23.7%) | 75 (23.9%) | 7 (21.9%) |  |
| Unemployed | 22 (6.4%) | 19 (6.1%) | 3 (9.4%) |  |
| Unknown | 74 (21.4%) | 67 (21.3%) | 7 (21.9%) |  |
| Insurance status |  |  |  | 0.261 |
| NHIA | 205 (59.2%) | 182 (58.0%) | 23 (71.9%) |  |
| Cash | 134 (38.7%) | 125 (39.8%) | 9 (28.1%) |  |
| Unknown | 7 (2.0%) | 7 (2.2%) | 0 (0.0%) |  |
| Disease process |  |  |  | 0.375 |
| Appendicitis | 107 (30.9%) | 99 (31.5%) | 8 (25.0%) |  |
| Bowel obstruction | 79 (22.8%) | 73 (23.2%) | 6 (18.8%) |  |
| Perforated PUD | 43 (12.4%) | 38 (12.1%) | 5 (15.6%) |  |
| Typhoid ileitis | 8 (2.3%) | 7 (2.2%) | 1 (3.1%) |  |
| Major trauma | 23 (6.6%) | 18 (5.7%) | 5 (15.6%) |  |
| Other\* | 86 (24.9%) | 79 (25.2%) | 7 (21.9%) |  |
| Hemoglobin level (range: 1.1 – 22.3) |  |  |  | 0.009 |
| <12.0 | 106 (30.6%) | 88 (28.0%) | 18 (56.3%) |  |
| 12.0-14.9 | 79 (22.8%) | 76 (24.2%) | 3 (9.4%) |  |
| 15.0+ | 61 (17.6%) | 56 (17.8%) | 5 (15.6%) |  |
| Unknown | 100 (28.9%) | 94 (29.9%) | 6 (18.8%) |  |
| White blood cell count (range: 1.48- 55.5) |  |  |  | 0.379 |
| <4.0 | 12 (3.5%) | 11 (3.5%) | 1 (3.1%) |  |
| 4-10.99 | 113 (32.7%) | 101 (32.2%) | 12 (37.5%) |  |
| 11-14.99 | 60 (17.3%) | 56 (17.8%) | 4 (12.5%) |  |
| 15.0+ | 61 (17.6%) | 52 (16.6%) | 9 (28.1%) |  |
| Unknown | 100 (28.9%) | 94 (29.9%) | 6 (18.8%) |  |
| Re-laparotomy | 32 (9.2%) | 24 (8.9%) | 8 (25.0%) | 0.005 |
| Surgical site infection | 36 (10.4%) | 28 (7.6%) | 8 (25.0%) | 0.001 |
| Bowel resection | 74 (21.4%) | 66 (21.0%) | 8 (25.0%) | 0.601 |
| Malignancy | 19 (5.5%) | 16 (5.1%) | 3 (9.4%) | 0.311 |
| Length of stay, mean (SD) days | 7.2 (8.2) | 6.7 (5.5) | 12.0 (20.4) | 0.024 |
| All data was obtained on index admission for surgical operation.  *SD* standard deviation  \*disease processes comprising the “other” category included intussusception, cholecystitis, bowel perforation, malignancy, fistula, intrabdominal infection, anastomotic dehiscence, intestinal ischemia, ovarian torsion, tubo-ovarian abscess, bowel stenosis, necrotizing pancreatitis, volvulus, and evisceration | | | | |

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| **Table 2.** Logistic regression modeling of readmission | | | | |
|  |  | **95% Confidence** | |  |
| Variable | OR | Lower | Upper | *P*-value |
| Age (years) |  |  |  |  |
| 0-17 | 0.87 | 0.22 | 3.47 | 0.840 |
| 18-39 | 1.43 | 0.48 | 4.20 | 0.520 |
| 40-59 | Reference |  |  |  |
| 60+ | 1.46 | 0.46 | 4.67 | 0.519 |
| Sex |  |  |  |  |
| Male | Reference |  |  |  |
| Female | 0.37 | 0.15 | 0.91 | 0.030 |
| Occupation |  |  |  |  |
| Laborer | 0.98 | 0.40 | 2.42 | 0.970 |
| Non-laborer | Reference |  |  |  |
| Insurance status |  |  |  |  |
| Self-pay | Reference |  |  |  |
| NHI | 2.60 | 1.002 | 6.76 | 0.049 |
| Hemoglobin level (g/dl) |  |  |  |  |
| 12+ | Reference |  |  |  |
| <12 | 3.50 | 1.54 | 7.96 | 0.003 |
| Re-laparotomy |  |  |  |  |
| Yes | 2.74 | 0.96 | 7.81 | 0.060 |
| No | Reference |  |  |  |
| Surgical site infection |  |  |  |  |
| Yes | 3.68 | 1.36 | 10.00 | 0.011 |
| No | Reference |  |  |  |
| Bowel resection |  |  |  |  |
| Yes | 0.91 | 0.34 | 2.44 | 0.858 |
| No | Reference |  |  |  |
| Malignancy |  |  |  |  |
| Yes | 2.31 | 0.50 | 10.68 | 0.283 |
| No | Reference |  |  |  |
| All data was obtained on index admission for surgical operation.  Hosmer Lemeshow goodness of fit statistic, *P* = 0.9746 | | | | |

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| **Table 3.** Linear regression modeling of length of stay | | | | |
|  |  | **95% Confidence** | |  |
| Variable | Coefficient | Lower | Upper | *P*-value |
| Age (years) |  |  |  |  |
| 0-17 | 0.29 | -2.49 | 3.08 | 0.835 |
| 18-39 | 1.36 | -0.82 | 3.54 | 0.222 |
| 40-59 | Reference |  |  |  |
| 60+ | 1.44 | -0.95 | 3.82 | 0.236 |
| Sex |  |  |  |  |
| Male | Reference |  |  |  |
| Female | 0.80 | -0.95 | 2.55 | 0.371 |
| Occupation |  |  |  |  |
| Laborer | -0.99 | -2.84 | 0.85 | 0.291 |
| Non-laborer | Reference |  |  |  |
| Insurance status |  |  |  |  |
| Self-pay | Reference |  |  |  |
| NHIS | 0.23 | -1.49 | 1.96 | 0.792 |
| Bowel obstruction |  |  |  |  |
| No | Reference |  |  |  |
| Yes | 2.77 | 0.73 | 4.81 | 0.008 |
| Hemoglobin level (g/dl) |  |  |  |  |
| 12+ | Reference |  |  |  |
| <12 | 2.98 | 1.16 | 4.80 | 0.001 |
| Re-laparotomy |  |  |  |  |
| Yes | 8.86 | 6.14 | 11.58 | < 0.001 |
| No | Reference |  |  |  |
| Surgical site infection |  |  |  |  |
| Yes | 0.95 | -1.87 | 3.76 | 0.509 |
| No | Reference |  |  |  |
| Bowel resection |  |  |  |  |
| Yes | 1.21 | -0.89 | 3.31 | 0.258 |
| No | Reference |  |  |  |
| Malignancy |  |  |  |  |
| Yes | 1.62 | -2.12 | 5.36 | 0.394 |
| No | Reference |  |  |  |
| R2= 0.1934  All data was obtained on index admission for surgical operation. | | | | |

**Figure Legend**

**Fig. 1:** Average Length of Stay for the Most Common Disease Processes. N = number of patients with given disease process. SD = standard deviation of length of stay in days.

