Predictors of Poor Postoperative Outcomes in Pediatric Surgery Patients in Rural Sub-Saharan Africa

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Abstract
Background/Purpose Perioperative complications cause significant pediatric morbidity and mortality in low- and lower middle-income countries. This study investigates factors associated with prolonged length of stay, 90-day readmission and in-hospital mortality among pediatric patients in eastern Ghana.

Methods This is a retrospective review of perioperative morbidity and mortality in children <18 years at Eastern Regional Hospital (ERH) in Koforidua, Ghana. All pediatric surgeries performed between January 2015 and December 2017 were included in this study and secondary analysis was performed.

Results We analyzed 468 patients <18 years of age with a median length of stay (LOS) of 3 days. The readmission and in-hospital mortality rates were 138 and 17 per 1000 patients, respectively. The most common procedures were herniorrhaphy (19%) and appendectomy (15%). Major procedures, gastrointestinal surgery, surgical trauma, surgical infection and having insurance were significantly associated with prolonged LOS. Age and male gender were significantly associated with in-hospital mortality. Malaria was significantly associated with 90-day readmission.

Conclusions Malaria infection is a significant and actionable risk factor for readmission in the pediatric surgical population in sub-Saharan Africa. Preventing readmission in patients with malaria could reduce readmission rates by 74%, leading to potential cost-savings and reductions in morbidity.

Introduction
Despite overall gains in global health, the burden of surgical diseases and complications in low- and lower middle-income countries (LMICs) remains high. In 2018, one in five surgical patients in LMICs had poor postoperative outcomes, such as surgical site infection (SSI), wound complication, or death [1]. An estimated 5 billion people do not have timely access to safe, affordable surgery [2]. The most substantial unmet need for surgical care is found in sub-Saharan Africa [2], in-which 43% of the population is under 15 years old [3]. The burden of surgical disease is high within the pediatric population [4], accounting for 6-12% of pediatric admissions in sub-Saharan Africa [5] with an overall mortality rate of 12% [6]. Unmet pediatric surgical need is a significant contributor to death and disability [5].
Pediatric surgery presents unique challenges which make it distinct from adult general surgery. Children present with different surgical pathologies, respond differently to anesthesia, and have special perioperative needs associated with high perioperative mortality [5, 7]. The vast majority of research on perioperative morbidity and mortality is from developed countries [7–12], and the number of studies that have looked at the influence of medical comorbidities unique to sub-Saharan Africa are limited [13–16]. Pediatric surgery in sub-Saharan Africa is disadvantaged by limited resources, high numbers of sick patients relative to the number of providers, and high frequency of delayed presentations with advanced pathologies [13]. Lack of finances and transportation are significant barriers to care, and cultural preference for traditional medicines and home remedies may significantly delay patient presentations [4, 17].

Previous studies have found that risk factors for perioperative mortality in sub-Saharan Africa include neonatal age group, delayed presentation, emergency surgery, high American Society of Anesthesiologists (ASA) status, and multiple operative procedures [6, 18, 19]. Other studies have suggested that increased postoperative complication rates occur with poor nutrition [20] and medical comorbidities such as HIV infection [15]. However, factors associated with pediatric surgical mortality and poor postoperative outcomes in sub-Saharan Africa may vary greatly across the continent. Therefore, this study contributes to the growing body of research by investigating factors associated with poor postoperative outcomes among pediatric patients in eastern Ghana.

1. Methods
1.1. Study design
A retrospective review was performed on the medical records of all patients < 18 years old who were admitted to the surgical ward from January 2015 through December 2017 at the Eastern Regional Hospital (ERH) in Koforidua, Ghana. ERH is a referral center for 26 district hospitals in the Eastern Region and has a surgical volume of over 2500 cases per year. It serves a catchment area with a population of approximately 3 million, more than 40% of which are children. A secondary analysis was conducted to examine possible associations between gender, insurance status, surgical procedure, malaria, anemia, white blood cell count (WBC), congenital or acquired conditions, type of procedure,
major or minor procedure, length of stay, readmission and mortality. The study protocol was reviewed and approved by the internal review board of Penn State Milton S. Hershey Medical Center and by the ERH for cultural appropriateness.

1.2. Study population
The study subjects were identified through billing records using patient identification numbers recorded in the ERH administration and management system. All patients < 18 years old who had surgery at ERH from January 1, 2015 to December 31, 2017 were included in this study. Patients were excluded from the analysis if they were admitted to the surgical ward but did not undergo a surgical procedure. The authors acknowledge that in Ghana only children < 12 years old are considered pediatric patients, however the authors elected to include patients up to age 17 in order to maximize the sample size and to allow for comparison to studies conducted in countries with broader definitions of pediatric patients.

1.3. Review of patient records
From the electronic medical records, information for each study subject was obtained including age, gender, insurance status, date of admission, date of surgery, date of discharge, length of stay, diagnosis, type of procedure, date of death, hemoglobin, WBC count, serum glucose, HIV, malaria, date of readmission, reason for readmission, and surgical site infection. For each patient, the diagnosis was categorized as congenital or acquired. Surgical procedures were classified as gastrointestinal, genitourinary, injury, neoplasm, surgical infection or miscellaneous. Major surgery was defined as entry into a body cavity (abdomen or thorax).

1.4. Statistical methods
A 2-tailed 2-sample Student's t-test or Wilcoxon rank-sum test was invoked to compare means or medians respectively for continuous outcomes variables between groups. We performed Pearson's chi-square tests or Fisher's exact tests for categorical variables. Values are expressed as the mean ± standard deviation (SD) for normally distributed variables, as median and interquartile range for skewed distribution, and as counts and percentages for categorical variables. Values that were found to be significant on univariate analysis were included in multivariable logistic regression models using backward elimination method. All multivariable analyses were adjusted for age (which was centered
by subtracting the mean age from raw age values) and gender. Point estimates are reported as odds ratios (OR) and 95% confidence intervals (CI) for each outcome (prolonged LOS, in-hospital mortality and 90-day readmission). The predictive models were cross-validated using leave-one out-cross-validation methods. To determine the discriminative power of the predictive models, the area under the receiver operating characteristic curve (AUC) was calculated. Statistical analysis was performed using SAS, version 9.4; SAS Institute Inc and R software (R Core Team 2018). For all statistical tests, alpha level was set at 0.05.

2. Results
During the study period, 595 pediatric patients presented to the pediatric ward at ERH. A total of 127 patients were excluded due to lack of a surgical procedure. Analysis was performed on the remaining 468 patients, whose clinical attributes are summarized in Table 1. Their ages ranged from 3 days to 17 years with a mean age of 9.0 years (standard deviation (SD) ± 5.3 years). Ninety percent of the patients in this study were male (Table 1). Of note, all of the patients tested for HIV in this study were found to be HIV negative. The median length of stay was 3 days (IQR ± 3 days). The 90-day readmission rate was 49 per 1000 patients. The in-hospital mortality rate was 17 per 1000 patients. Thirty-eight percent of those who died were infants. Mortality in children older than one year was 9 per 1000 patients, which was much lower than in children less than or equal to one year, which was 235 per 1000 patients.
Table 1
Clinical Attributes: Demographics

| Attribute                      | Cohort (n = 468) |
|-------------------------------|------------------|
| Age years, Mean (SD)          | 9.0 (5.3)        |
| Age Range                     |                  |
| ≤ 1 yr                        | 17 (3.6)         |
| 2-3 yrs                       | 79 (17)          |
| 4-8 yrs                       | 138 (29)         |
| 9-13 yrs                      | 105 (22)         |
| 14-17 yrs                     | 129 (28)         |
| Sex                           |                  |
| Male, n (%)                   | 422 (90)         |
| Female, n (%)                 | 46 (10)          |
| Malaria, n (%)                | 25/207 (12)      |
| HIV, n (%)                    | 0/130 (0)        |
| Insurance, n (%)              | 356 (76)         |
| Anemia, n (%)                 | 127/194 (65)     |
| Leukopenia, n (%)             | 13/194 (7)       |
| Leukocytosis, n (%)           | 92/194 (47)      |
| Surgical Site Infection, n (%)| 2 (0.4)          |
| Congenital vs Acquired        |                  |
| Acquired, n (%)               | 420 (90)         |
| Congenital, n (%)             | 48 (10)          |
| Procedure Category            |                  |
| Gastrointestinal              | 274 (59)         |
| Genitourinary                 | 61 (13)          |
| Injury                        | 71 (15)          |
| Miscellaneous                 | 32 (7)           |
| Neoplasm                      | 19 (4)           |
| Surgical Infection            | 11 (2)           |
| Major/Minor                   |                  |
| Major                         | 138 (29)         |
| Minor                         | 330 (71)         |
| Length of stay, median (IQR)  | 3.0 (3.0)        |
| In-hospital Mortality, n (%)  | 8 (2)            |
| 90-day Readmission, n (%)     | 23 (5)           |

The pediatric surgical conditions were categorized by whether they were congenital (10%) or acquired (90%). The distribution of the types of pediatric surgical conditions are shown in Fig. 1. Abdominal surgery was the most common category, with the leading surgical procedures being herniorrhaphy (89/468, 19%) and appendectomy (72/468, 15%). Overall, 136 (29%) were major surgical procedures, as defined by entry into the abdominal or thoracic cavity.

Summarized in Table 2 is the univariate analysis for the factors associated with LOS ≥ 4 days. Older age, lack of insurance, anemia (Hgb < 12 mg/dl), leukocytosis (≥ 11,000 leukocytes/µL), surgical procedure category and major procedures were significantly associated with prolonged LOS. Similarly, summarized in Table 3 is the univariate analysis for predictors of in-hospital mortality. Younger age, female sex and major procedures were significantly associated with in-hospital mortality. Similarly, summarized in Table 4 is the univariate analysis for predictors of 90-day readmission. Younger age
and malaria infection were significantly associated with readmission within 90 days.

Table 2
Univariate Analysis for the Predictors of Length of Stay Greater Than or Equal to 4 Days

| Attribute                      | Cohort (n = 468) | Length of Stay < 4 days (n = 279) | Length of Stay ≥ 4 days (n = 189) | pValue |
|--------------------------------|------------------|-----------------------------------|-----------------------------------|--------|
| Age years. mean (SD)           | 468              | 8.5 (5.2)                         | 9.6 (5.4)                         | 0.0256 |
| Sex                            |                  |                                   |                                   |        |
| Male (%)                       | 422              | 253 (60)                          | 169 (40)                          | 0.6525 |
| Female (%)                     | 46               | 26 (57)                           | 20 (43)                           |        |
| Insured                        |                  |                                   |                                   |        |
| No (%)                         | 112              | 52 (46)                           | 60 (54)                           | 0.0011 |
| Yes (%)                        | 356              | 227 (64)                          | 129 (36)                          |        |
| Malaria                        |                  |                                   |                                   |        |
| No (%)                         | 182              | 105 (58)                          | 77 (42)                           | 0.8265 |
| Yes (%)                        | 25               | 15 (60)                           | 10 (40)                           |        |
| Anemia                         |                  |                                   |                                   |        |
| No (%)                         | 67               | 40 (60)                           | 27 (40)                           | 0.0095 |
| Yes (%)                        | 127              | 51 (40)                           | 76 (60)                           |        |
| Leukopenia                     |                  |                                   |                                   |        |
| No (%)                         | 181              | 83 (46)                           | 98 (54)                           | 0.2738 |
| Yes (%)                        | 13               | 8 (62)                            | 5 (38)                            |        |
| Leukocytosis                   |                  |                                   |                                   |        |
| No (%)                         | 102              | 56 (55)                           | 46 (45)                           | 0.0188 |
| Yes (%)                        | 92               | 35 (38)                           | 57 (62)                           |        |
| Congenital vs Acquired         |                  |                                   |                                   |        |
| Acquired (%)                   | 420              | 246 (59)                          | 174 (41)                          | 0.1734 |
| Congenital (%)                 | 48               | 33 (69)                           | 15 (31)                           |        |
| Procedure Category             |                  |                                   |                                   |        |
| Gastrointestinal (%)           | 274              | 151 (55)                          | 123 (45)                          | 0.0011 |
| Genitourinary (%)              | 61               | 50 (81)                           | 11 (18)                           |        |
| Injury (%)                     | 71               | 42 (59)                           | 29 (41)                           |        |
| Miscellaneous (%)              | 32               | 21 (66)                           | 11 (34)                           |        |
| Neoplasm (%)                   | 19               | 12 (63)                           | 7 (37)                            |        |
| Surgical Infection (%)         | 11               | 3 (27)                            | 8 (73)                            |        |
| Major/Minor                    |                  |                                   |                                   |        |
| Major (%)                      | 136              | 33 (24)                           | 105 (76)                          | < 0.0001|
| Minor (%)                      | 332              | 246 (75)                          | 84 (25)                           |        |
| Attribute                                      | Cohort (n = 468) | Alive (n = 460) | Died (n = 8) | pValue |
|-----------------------------------------------|------------------|-----------------|--------------|--------|
| Age years. mean (SD)                          | 468              | 9.1 (5.2)       | 2.7 (3.0)    | 0.0004 |
| Sex                                           |                  |                 |              |        |
| Male (%)                                      | 422              | 418 (99)        | 4 (1)        | 0.0043 |
| Female (%)                                    | 46               | 42 (91)         | 4 (9)        |        |
| Insured                                       |                  |                 |              |        |
| No (%)                                        | 112              | 109 (97)        | 3 (3)        | 0.4042 |
| Yes (%)                                       | 356              | 351 (99)        | 5 (1)        |        |
| Malaria                                       |                  |                 |              |        |
| No (%)                                        | 182              | 179 (98)        | 3 (2)        | 1.0000 |
| Yes (%)                                       | 25               | 25 (100)        | 0 (0)        |        |
| Anemia                                        |                  |                 |              |        |
| No (%)                                        | 67               | 65 (97)         | 2 (3)        | 1.0000 |
| Yes (%)                                       | 127              | 124 (98)        | 3 (2)        |        |
| Leukopenia                                    |                  |                 |              |        |
| No (%)                                        | 181              | 177 (98)        | 4 (2)        | 0.2957 |
| Yes (%)                                       | 13               | 12 (92)         | 1 (8)        |        |
| Leukocytosis                                  |                  |                 |              |        |
| No (%)                                        | 102              | 100 (98)        | 2 (2)        | 0.6694 |
| Yes (%)                                       | 92               | 89 (97)         | 3 (3)        |        |
| Congenital vs Acquired                        |                  |                 |              |        |
| Acquired (%)                                  | 420              | 414 (99)        | 6 (1)        | 0.1936 |
| Congenital (%)                                | 48               | 46 (96)         | 2 (4)        |        |
| Procedure Category                            |                  |                 |              |        |
| Gastrointestinal (%)                          | 274              | 266 (97)        | 8 (3)        | 0.5798 |
| Genitourinary (%)                             | 61               | 61 (100)        | 0 (0)        |        |
| Injury (%)                                    | 71               | 71 (100)        | 0 (0)        |        |
| Miscellaneous (%)                             | 32               | 32 (100)        | 0 (0)        |        |
| Neoplasm (%)                                  | 19               | 19 (100)        | 0 (0)        |        |
| Surgical Infection (%)                        | 11               | 11 (100)        | 0 (0)        |        |
| Major/Minor                                   |                  |                 |              |        |
| Major (%)                                     | 136              | 130 (94)        | 8 (6)        | <0.0001|
| Minor (%)                                     | 332              | 330 (100)       | 0 (0)        |        |
Table 4
Univariate Analysis for the Predictors of Readmission Within 90 Days

| Attribute              | Cohort (n = 468) | Not readmitted (n = 445) | Readmitted (n = 23) | p Value |
|------------------------|------------------|--------------------------|---------------------|---------|
| Age years. mean (SD)   | 468              | 9.1 (5.3)                | 7.0 (4.7)           | 0.0494  |
| Sex                    |                  |                          |                     |         |
| Male (%)               | 422              | 399 (95)                 | 23 (5)              | 0.1511  |
| Female (%)             | 46               | 46 (100)                 | 0 (0)               |         |
| Insured                |                  |                          |                     |         |
| No (%)                 | 112              | 109 (97)                 | 3 (3)               | 0.2094  |
| Yes (%)                | 356              | 336 (94)                 | 20 (6)              |         |
| Malaria                |                  |                          |                     |         |
| No (%)                 | 182              | 170 (93)                 | 12 (7)              | 0.0116  |
| Yes (%)                | 25               | 19 (76)                  | 6 (24)              |         |
| Anemia                 |                  |                          |                     |         |
| No (%)                 | 67               | 64 (96)                  | 3 (4)               | 0.5492  |
| Yes (%)                | 127              | 118 (93)                 | 9 (7)               |         |
| Leukopenia             |                  |                          |                     |         |
| No (%)                 | 181              | 169 (93)                 | 12 (7)              | 1.0000  |
| Yes (%)                | 13               | 13 (100)                 | 0 (0)               |         |
| Leukocytosis           |                  |                          |                     |         |
| No (%)                 | 102              | 95 (93)                  | 7 (7)               | 0.6801  |
| Yes (%)                | 92               | 87 (95)                  | 5 (5)               |         |
| Congenital vs Acquired |                  |                          |                     |         |
| Acquired (%)           | 420              | 400 (95)                 | 20 (5)              | 0.7202  |
| Congenital (%)         | 48               | 45 (94)                  | 3 (6)               |         |
| Procedure Category     |                  |                          |                     |         |
| Gastrointestinal (%)   | 274              | 259 (95)                 | 15 (5)              | 0.7268  |
| Genitourinary (%)      | 61               | 59 (97)                  | 2 (3)               |         |
| Injury (%)             | 71               | 69 (97)                  | 2 (3)               |         |
| Miscellaneous (%)      | 32               | 30 (94)                  | 2 (6)               |         |
| Neoplasm (%)           | 19               | 18 (95)                  | 1 (5)               |         |
| Surgical Infection (%) | 11               | 10 (91)                  | 1 (9)               |         |
| Major/Minor            |                  |                          |                     |         |
| Major (%)              | 136              | 129 (93)                 | 9 (7)               | 0.2983  |
| Minor (%)              | 332              | 316 (96)                 | 14 (4)              |         |

On multivariable logistic regression, major procedures (OR: 9.61, 95% CI = 3.77–24.53, p = < 0.0001), gastrointestinal surgery (OR: 3.72, 95% CI = 1.92–7.82, p = 0.0002), surgical traumas (OR: 3.13, 95% CI = 1.43–7.27, p = 0.005), surgical infection (OR: 12.12, 95% CI = 3.00–62.64, p = 0.0009) and insurance (OR: 0.41, 95% CI = 0.18–0.94, p = 0.04) were predictors of prolonged LOS with the area under the curve (AUC) of 80% (Table 5). In addition, anemia (OR: 1.95, 95% CI = 0.93–4.09, p = 0.08), miscellaneous procedures (OR: 2.38, 95% CI = 0.89–6.42, p = 0.08) and oncologic procedures (OR: 2.56, 95% CI = 0.83–8.29, p = 0.09) were marginally significant predictors of prolonged LOS. Age (OR: 0.65, 95% CI = 0.50–0.85, p = 0.002) and male gender (OR: 0.066, 95% CI = 0.005–0.79, p = 0.03) were independent predictors of in-hospital mortality with the AUC of 98% (Table 5). Malaria infection (OR: 4.04, 95% CI = 1.28–12.74, p = 0.02) was found to be an independent predictor of readmission within 90 days with the AUC of 74% (Table 5). In addition, age (OR: 0.91, 95% CI = 0.81–1.01, p = 0.
0853) was found to be a marginally significant predictor of readmission within 90 days.

3. Discussion

This is one of the first studies of perioperative outcomes in pediatric patients in rural Ghana. This study had several significant findings. First, that malaria infection is an actionable independent predictor of readmission in the pediatric surgical population in sub-Saharan Africa. The burden of malaria infection in this region is highest in the pediatric population due to the immunological and behavioral drivers[21]. The underlying mechanism of readmission among patients with malaria is not fully understood. However, the pathophysiological changes caused by malaria infections, including excessive releases of cytokines and chemokines such as tumor necrosis factors and interleukin-2, could alter the healing process postoperatively [22]. Previous studies have suggested that surgery may weaken patients’ immune systems, increasing their susceptibility to malaria and its complications or to other pathogens [16].

By adequately treating malaria preoperatively, readmission rates can be reduced by 74 percent, leading to potential cost savings and reductions in morbidity. At Eastern Regional Hospital, the average cost is $16 USD per day of admission and an average length of stay of 4.3 days, the total direct cost of a hospital admission is approximately $69 USD not including transportation or lost wages. According to 2016 World Bank calculations, Ghana’s annual gross national income (GNI) per capita is $1840 USD with a GINI coefficient of 0.435 [23]. In 2013, 21.7% of the population of the Eastern Region was living on less than 1,314 GHS ($241 USD) per adult per year [24]. Therefore, a $69 hospital admission would put a substantial financial burden on the family.

Table 5

| Independent Predictor of Outcomes | OR (95% CI)     | p-Value | Area Under the Curve |
|----------------------------------|----------------|---------|----------------------|
| Length of Stay                   |                |         | 80%                  |
| Major Procedure                  | 9.61 (3.77, 24.53) | < 0.0001 |                      |
| Gastrointestinal Injury          | 3.72 (1.92, 7.82)  | 0.0002  |                      |
| Surgical Infection               | 12.12 (3.00, 62.64) | 0.0009  |                      |
| Insurance                        | 0.41 (0.18, 0.94)   | 0.0351  |                      |
| Mortality                        |                |         | 98%                  |
| Male                             | 0.066 (0.005, 0.79) | 0.0321  |                      |
| Age                              | 0.65 (0.50, 0.85)    | 0.0016  |                      |
| Readmission                      |                |         | 74%                  |
| Malaria                          | 4.04 (1.28, 12.74)  | 0.0172  |                      |
Consistent with previous studies, our study found an association between age and mortality [7, 11, 14, 19, 25, 26]. This may be the result of young children's immature immune systems [27] or complex congenital disease processes [26]. It is likely that social processes common throughout sub-Saharan Africa such as lack of neonatal intensive care unit, lack of pediatric surgical specialists or delay in presentation contributed as well [19]. Due to the lack of subspecialized pediatric surgeons at ERH, it is possible that infants and neonates with surgical conditions in this region are less likely to be brought to this hospital for treatment or are more likely to be transferred to the national hospital with pediatric surgery specialists, contributing to low numbers of infants and neonates operated on at this facility. To our surprise, we also found an association between female gender and perioperative mortality, which is in contrast with previous studies [5, 7, 19, 26, 28]. Additional studies are needed to further investigate the relationship between gender and mortality in this region.

This study also identified several independent predictors of prolonged LOS, including major surgery, gastrointestinal surgery, surgical injuries, surgical infections, and lack of insurance. It is to be expected that major surgery is associated with prolonged, as major surgery is associated with an increased procedural complexity, increased risk of technical problems, longer surgical and anesthetic time, and immune deregulation resulting from the stress response to surgery or owing to impaired respiratory function in the postoperative period [29]. Similarly, it is to be expected that gastrointestinal surgeries are associated with prolonged LOS relative to genitourinary surgeries as gastrointestinal surgeries are more likely to involve major surgery. In addition, surgical injuries can range from minor lacerations to complex polytraumas and surgical infections can range from localized abscesses to severe sepsis, with the more severe cases requiring extended admissions for medical management. However, it is possible that creating standardized management protocols can help to reduce the LOS in select cases. It is interesting to note that lack of insurance is associated with prolonged LOS. It is possible that lack of insurance may cause delayed presentation and therefore patients may present with more advanced disease, however it is also possible that patients without insurance are unable to pay their bills on time and therefore are kept in the hospital until their bills
are paid. Additional studies need to be performed to further elucidate this association.

In comparing the results of this study to the literature, the average LOS for all pediatric surgical admissions in this study, 4.3 days, is similar to that reported by other studies [14, 30]. The overall in-hospital mortality rate of 1.7% observed in this study was lower than the mortality rate of 12% reported in a systematic review of pediatric surgeries in LMICs in Africa [6]. This could be explained in part by region-specific differences, as the mortality rate in this study is similar to another West African study looking at pediatric general surgical cases in Nigeria, suggesting that there may be some genetic and environmental differences [19]. It is important to note that no patients in this study tested positive for HIV, therefore this data neither supports nor refutes the claims that HIV increases the risk of postoperative complications [15].

This study had several limitations. First, this was a retrospective study and therefore is subject to a lack of sufficient clinical details and is potentially vulnerable to confounding. Second, the mortality data collected was limited to in-hospital mortality, and as a result, mortality rates could have been underestimated. Some patients could have died at home and would not have been captured in the hospital records. Third, all patients who were admitted to the surgical ward but did not undergo a procedure were excluded, therefore if a patient died prior to their scheduled procedure, their death would not be reflected on the calculated in-hospital mortality rate. Consequently, it is recommended that a prospective multicenter study with detailed follow-up be performed to increase the precision and external validity of the results.

4. Conclusion
While many of the risk factors for perioperative morbidity identified in this study are not actionable, malaria infection is a major and actionable risk factor for readmission in the pediatric surgical population in sub-Saharan Africa. By preventing readmission in patients with malaria, we could reduce the prevalence of readmission by 74%, leading to potential cost-savings and reductions in morbidity. Randomized control trials and prospective studies need to be completed to determine how to prevent readmission in patients with malaria. Future studies should also focus on further clarifying the association between female gender and mortality and the association between lack of insurance and
prolonged length of stay in Ghana as well as to determine whether these associations are present in other regions.

**Declarations**

*Ethics Approval and Consent to Participate*

The study protocol was reviewed and approved by the internal review board of Penn State Milton S. Hershey Medical Center and by the Eastern Regional Hospital for cultural appropriateness.

*Consent for Publication*

Not applicable.

*Availability of Data and Materials*

The datasets generated and analyzed during the current study are not publicly available to protect the privacy of the study participants but are available from the corresponding author on reasonable request.

*Competing Interests*

The authors declare no conflict of interest.

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*Authors’ Contributions*

**Sarah Peiffer:** Conceptualization, Methodology, Formal Analysis, Investigation, Data Curation, Writing- Original Draft, Visualization **Anna Ssentongo:** Formal Analysis, Writing - Review & Editing

**Laura Keeney:** Conceptualization, Writing - Review & Editing **Forster Amponsah-Manu:** Investigation, Resources, Writing - Review & Editing, Supervision **Richard Yeboako:** Resources, Project Administration **Richard Ofosu-Akromah:** Investigation, Resources **Temitope Ebenezer Arkorful:** Investigation, Resources **Eric Agyemang:** Writing - Review & Editing, Supervision **John Oh:** Conceptualization, Writing - Review & Editing, Supervision **Anthony Tsai:** Writing - Review & Editing, Supervision **Paddy Ssentongo:** Conceptualization, Methodology, Formal Analysis, Writing - Review & Editing, Supervision, Project administration, Guarantor

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Figures
Figure 1

Distribution of Types of Pediatric Surgical Admissions