Introduction
In recent years, there has been an increasing focus on the global burden of surgical diseases [1]. In 2015, the Lancet Commission on Global Surgery showed that the world’s poorest 5 billion people lack access to safe, affordable surgical and anesthesia care [2]. In developing a strategy to meet this need, the perioperative mortality rate (POMR) was identified as one of six core indicators for monitoring universal access to safe surgical care and anesthesia care. As a global indicator, the POMR is defined as the in-hospital mortality due to any cause during surgery over the number of patients undergoing an operation [3]. The POMR can thus be used as a tool to identify procedures that carry the highest mortality rates; identifying the causes of mortality can assist in setting priorities for improving outcomes.

Even before the inception of the six core indicators, overall improvement in surgical services in sub-Saharan Africa was a priority. The Bellagio Essential Surgery Group (BESG) described a need for quantification of surgical outcomes not only on a country level but also between populations with different characteristics, for example, urban and rural [4].

In Ghana, the majority of studies on surgical outcomes and POMR has come from teaching hospitals in Kumasi and Accra—two large hospitals located in urban regions. [5–8]. The generalizability of this data to hospitals serving more rural Ghana is not clear.

Eastern Regional Hospital (ERH) serves as a surgical referral center located in Koforidua, Ghana, for the 2.5 million people of Eastern Region, Ghana, of which 56% is classified as rural [9]. On average patients travel 98 km to arrive at the facility. Surgical disease is frequently a reason for referral as many district hospitals are not equipped with the facilities or personnel required for major abdominal operations [10]. Therefore, one of the most common operations performed at this facility is emergent exploratory laparotomy. Late disease presentation combined with a frequent lack of pre-operative imaging makes these operations particularly challenging.
The purpose of this study was to quantify surgical outcomes for exploratory laparotomy with a specific focus on POMR for a rural referral center in Ghana. Our aim was to assess the factors associated with POMR in order to identify potential areas for process improvement.

Methods
Data sources
Data were obtained retrospectively from the surgical logbook at ERH in Koforidua, Ghana. Included in the data was a medical record number, which was used to obtain patient electronic medical records (EMR). Data from the surgical logbook and the electronic medical records were compiled and corroborated.

Approval for use of the data was given by the institutional review board at The Pennsylvania State University College of Medicine (STUDY00009316) as well as by ERH leadership.

Population
The study included all patients who underwent an exploratory laparotomy between July 1, 2017 and June 30, 2018 at ERH. Exploratory laparotomy was defined as an open abdominal operation in an emergent or urgent setting. Patients with planned open abdominal operations, such as stoma reversals, were not included in the study. All operations were supervised by a single general surgeon. Pediatric (0–17) and adult (18+) sub-groups were created for analysis. Patients were excluded for discrepancies between the logbook and EMR.

The population was further stratified for a secondary analysis beginning in December of 2017. Patients who were initially seen at an outside hospital, as opposed to patients who initially presented to ERH, were considered as referrals.

Outcomes
Peri-operative in-hospital mortality was the primary outcome of the study. Secondary outcomes included hospital length of stay (LOS), 30-day readmission, 30-day re-laparotomy, surgical site infection (SSI), and bowel resection.

Covariates
Analyses controlled for demographic and clinical covariates. Demographic covariates included age, sex (male, female), marital status (single, married, widowed, divorced, unknown), occupation (laborer, professional, student, unemployed, unknown), and insurance (National Health Insurance [NHI], cash). Clinical covariates included hemoglobin levels prior to operation (0–11.9, 12.0–14.9, 15+, unknown), white blood cell (WBC) counts prior to operation (0–3.99, 4–10.99, 11–14.99, 15+, unknown) and post-operative diagnosis (appendicitis, obstruction, perforated peptic ulcer disease, typhoid ileitis, major trauma, intussusception, other). Covariates used in multivariable modeling were limited in order to avoid overfitting the model.

Statistical analysis
The key aims of the study were, first, determine the most common diagnoses associated with exploratory laparotomy, second, assess the impact of those diagnoses on POMR, third, identify the rates of other short-term perioperative outcomes, and fourth, determine the impact of referrals on the surgical mortality rate at ERH.

Chi squared tests were used to compare outcomes between adult and pediatric patients. Multivariable logistic regression modeling of mortality was performed for all patients. The sub-group analysis of impact of referrals on mortality was assessed with a chi squared test. 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 identified 346 patients (286 adult and 60 pediatric) who underwent exploratory laparotomy between July of 2017 and June of 2018 and met inclusion criteria. Table 1 shows characteristics of patients undergoing exploratory laparotomy. The average age of the adult patient was 46.5 years (SD 18.2). Males accounted for slightly more than 60% of all patients. Adults were most commonly married and employed as laborers. Of all adults, 59.1% were insured by the National Health Insurance Authority (NHIA) at the time of operation. Conversely, 38.8% had to cover health care costs out-of-pocket. Seventy percent had laboratory evaluation of hemoglobin and WBC levels prior to surgery. Of those patients, 28.3% were anemic (hemoglobin level less than 12.0) and 32.9% had an elevated WBC count (WBC greater than or equal to 11.0).

The average age of the pediatric patient was 9.4 years (SD 5.7) and 75% were males. The vast majority were single (93.3%) but there were teenagers who identified as married or divorced (5.0%). Overwhelmingly, this population identified as students and, similar to the adult population, 60.0% were insured at the time of operation while 38.3% paid for health care costs out-of-pocket. 80.0% of patients had laboratory evaluation prior to surgery. Of those, 73.4% were anemic with a hemoglobin of less than 12.0 and 45.0% had a leukocytosis with a WBC greater than or equal to 11.0.

Figure 1 shows diagnoses associated with exploratory laparotomy in the adult population. Appendicitis (29.0%), obstruction (26.2%), perforated peptic ulcer disease (14.7%), and major trauma (5.9%) were the most common indications for an operation. Of note, the cases of appendicitis were complicated by abscess or perforation 59.0% of the time. Causes of obstruction were as follows: hernia (43.0%), adhesions (43.0%), and neoplasmia (14.0%). Interestingly, there was only one non-therapeutic exploratory laparotomy performed on a patient with pancreatitis.

Indications for an operation in the pediatric population are depicted in Figure 2. Appendicitis (40%), intussusception (16.7%), major trauma (10%), and typhoid ileitis (6.7%) were most common. There were no negative exploratory laparatomies in the pediatric population.

Rates of perioperative surgical outcomes are listed in Table 2. In the adult population, the mortality rate associated with exploratory laparotomy was 12.6%. The average

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LOS for a surgical patient was 7.2 days and patients were readmitted within 30 days at a rate of 9.4%. SSIs occurred in 9.8% of adults. In total, 21% of operations included a bowel resection.

In the pediatric group, the mortality rate was 6.7% and the LOS averaged 6.9 days. Within 30 days, 8.3% of patients were readmitted to the hospital. SSIs were detected at a rate of 6.7%. About 21.3% of all exploratory laparotomy operations in adults and 21.7% in children included a bowel resection. There were no statistically significant differences between the outcomes of adults and children.

Further stratification of POMR by disease is shown in Table 3. The four most common reasons for exploratory laparotomy for adults and children are shown with respective number of operations and mortality rates. In adults, exploratory laparotomy following major trauma was associated with the highest mortality rate at 17.6%. Intussusception had the highest mortality rate in children at 20.0%.

The results of multivariable modeling of mortality for all patients is shown in Table 4. Female sex (OR = 0.36; p = 0.023) and NHI (OR = 0.41; p = 0.041) were protective against mortality. Unsurprisingly, age 60+ and leukopenia

Table 1: Baseline characteristics of patients prior to exploratory laparotomy.

| Variable            | Adult (n = 286) | Pediatric (n = 60) |
|---------------------|-----------------|--------------------|
|                     | n   | %   | n   | %   |
| Age (mean years)    | 46.5| 9.4 | 9.4 |
| Sex                 |     |     |     |     |
| Male                | 179 | 62.6%| 45  | 75.0%|
| Female              | 107 | 37.4%| 15  | 25.0%|
| Marital status      |     |     |     |     |
| Single              | 77  | 26.9%| 56  | 93.3%|
| Married             | 168 | 58.7%| 2   | 3.3% |
| Widowed             | 23  | 8.0% | 0   | 0.0% |
| Divorced            | 11  | 3.8% | 1   | 1.7% |
| Unknown             | 7   | 2.4% | 1   | 1.7% |
| Occupation          |     |     |     |     |
| Laborer             | 143 | 50.0%| 0   | 0.0% |
| Professional        | 25  | 8.7% | 0   | 0.0% |
| Student             | 30  | 10.5%| 52  | 86.7%|
| Unemployed          | 21  | 7.3% | 1   | 1.7% |
| Unknown             | 67  | 23.4%| 7   | 11.7%|
| Insurance status    |     |     |     |     |
| NHIA                | 169 | 59.1%| 36  | 60.0%|
| Cash                | 111 | 38.8%| 23  | 38.3%|
| Unknown             | 6   | 2.1% | 1   | 1.7% |
| Hemoglobin level    |     |     |     |     |
| 0–11.9              | 81  | 28.3%| 25  | 41.7%|
| 12.0–14.9           | 60  | 21.0%| 19  | 31.7%|
| 15.0+               | 57  | 19.9%| 4   | 6.7% |
| Unknown             | 88  | 30.8%| 12  | 20.0%|
| White blood cell count |   |     |     |     |
| 0–3.99              | 13  | 4.5% | 0   | 0.0% |
| 4–10.99             | 92  | 32.2%| 21  | 35.0%|
| 11–14.99            | 52  | 18.2%| 8   | 13.3%|
| 15.0+               | 42  | 14.7%| 19  | 31.7%|
| Unknown             | 88  | 30.8%| 12  | 20.0%|

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were predictive of mortality (OR = 3.34, p = 0.017 and OR = 5.06, p = 0.031).

Compared to the reference operation, several diagnoses impacted mortality. Obstruction (OR = 12.23, p = 0.022), perforated peptic ulcer disease (OR = 13.09, p = 0.025), major trauma (OR = 12.14, p = 0.039), and intussusception (OR = 34.29, p = 0.012) significantly increased the odds of death.

Table 3: Perioperative mortality rates associated with the most common causes of exploratory laparotomy.

| Disease process | Adult | Pediatric |
|-----------------|-------|-----------|
|                 | (Total operations = 286, Overall mortality rate = 12.6%) | (Total operations = 60, Overall mortality rate = 6.7%) |
| Appendicitis    | 83    | 0.0%      | 1. Appendicitis | 24 | 4.2% |
| Obstruction     | 75    | 14.7%     | 2. Intussusception | 10 | 20.0% |
| Perforated PUD  | 42    | 14.3%     | 3. Major trauma | 6 | 0.0% |
| Major trauma    | 17    | 17.6%     | 4. Typhoid ileitis | 4 | 0.0% |

Table 4: Logistic regression modeling of mortality.

| Variable                      | 95% confidence interval |
|-------------------------------|-------------------------|
|                               | OR | Lower | Upper | p-value |
| Age (years)                   |    |       |       |         |
| 0–17                          | 0.43 | 0.09 | 2.00 | 0.280 |
| 18–39                         | 0.45 | 0.14 | 1.47 | 0.184 |
| 40–59                         | Reference |       |       |         |
| 60+                           | 3.34 | 1.25 | 8.94 | 0.017 |
| Sex                           |    |       |       |         |
| Male                          | Reference |       |       |         |
| Female                        | 0.36 | 0.15 | 0.87 | 0.023 |
| Insurance status              |    |       |       |         |
| NHI                           | 0.41 | 0.17 | 0.96 | 0.041 |
| Cash                          | Reference |       |       |         |
| Diagnosis                     |    |       |       |         |
| Appendicitis                  | Reference |       |       |         |
| Obstruction                   | 12.23 | 1.44 | 104.20 | 0.022 |
| Perforated PUD                | 13.09 | 1.38 | 124.44 | 0.025 |
| Typhoid ileitis               | 18.87 | 0.94 | 377.46 | 0.055 |
| Major trauma                  | 12.14 | 1.14 | 129.78 | 0.039 |
| Intussusception               | 34.29 | 2.18 | 539.35 | 0.012 |
| Other                         | 24.85 | 3.03 | 203.78 | 0.003 |
| Hemoglobin level              |    |       |       |         |
| 0–11.9                        | 0.67 | 0.26 | 1.69 | 0.394 |
| 12.0–14.9                     | Reference |       |       |         |
| 15.0+                         | 0.18 | 0.04 | 0.71 | 0.015 |
| White blood cell count        |    |       |       |         |
| 0–3.99                        | 5.06 | 1.16 | 21.98 | 0.031 |
| 4–10.99                       | Reference |       |       |         |
| 11–14.9                       | 1.32 | 0.45 | 3.90 | 0.616 |
| 15.0+                         | 2.13 | 0.67 | 6.78 | 0.199 |
Secondary analysis of the impact of referrals on mortality included 225 patients from the initial analysis (126 referrals and 99 non-referrals). Referred patients accounted for 60% of all mortalities. On average 54% of all patients undergoing exploratory laparotomy were first seen at an outside facility prior to their operation. Trends in mortality rates for referral and non-referral patients are shown in Figure 3. Overall, the mortality rate for referred patients was 13.5% and the mortality rate for non-referred patients was 11.1%. These mortality rates were not significantly different (p = 0.591).

Discussion
At first glance, an overall surgical mortality rate of 12.6% for exploratory laparotomy in the adult population of our study seems high given prior estimates of global POMR of 0.8%–1.5% [11]. However, that study included all operations, across varying degrees of operative urgency, and with extensive variation in surgical disease. More likely, the elevated mortality rate demonstrates the complexity and advanced degree of surgical disease requiring laparotomy at ERH. In fact, in a study using data from 83 low- and middle-income countries (LMIC), the POMR for laparotomy was estimated to be 11.6%, which closely mirrors the mortality rate of laparotomy at ERH [12].

Appendicitis, obstruction, perforated peptic ulcer disease, and major trauma were the most common surgical disease processes in adults. Additionally, intussusception and typhoid ileitis were common in the rural pediatric population of ERH. Similarly, appendicitis, typhoid ileitis, obstruction, and gastroduodenal perforations were reported as the major reasons for emergent laparotomy in a larger facility serving a nearby urban population in Ghana [5]. The notable exception was the significantly higher rates of typhoid ileitis at the urban facility.

Operative intervention for appendicitis was remarkable in that it was the most common reason for surgery in both the adult and pediatric population. While the POMR for these operations was very low, these operations were not without associated mortality in the pediatric population. Likely contributing to this was the associated 59% rate of complicated appendicitis found at the time of surgery. In the near future we aim to investigate the drivers of complicated appendicitis, including delayed presentation.

Overall, the major causes of obstruction identified at ERH were hernia (43%), adhesions (43%), and neoplasia (14%). Interestingly, in the more urban capital of Accra, the rates of obstruction due to hernia have dramatically decreased such that hernias are now the eighth most common reason for obstruction. This has been attributed to an increase in the surgical workforce and a conscious effort to reduce hernia “backlog” in the capital [13]. Unfortunately, the changes in urban Ghana do not yet appear to have reached rural Ghana where emergent and urgent operations for hernias likely increase POMR. While it would be ideal to similarly increase the surgical workforce at ERH, perhaps more realistically, we could aim to better educate the population to have hernias repaired earlier and in an elective fashion. Engaging community health workers could be effective with outreach and education in rural communities [14].

Perforated peptic ulcer disease resulted in one of the highest mortality rates at 14.3%. A comparison rate of 13.6% was reported in a systematic review of the literature of sub-Saharan Africa [15]. More importantly, the high mortality rate was associated with an impressive case load as PUD accounted for nearly 15% of all exploratory laparotomies. The high incidence of perforation is likely multifactorial. H. pylori prevalence ranges between 45%–80% in Ghana [16–17]. The use of herbal remedies and NSAIDs is also thought to contribute to the problem [18]. Going forward, a multi-disciplinary approach to earlier identification and treatment of peptic ulcer disease could greatly impact POMRs and surgical burden.

The POMR for major abdominal trauma requiring operative intervention in our study was approximately four times that reported in nearby urban centers (17.6% versus...
4.4%) [6]. The contributions of limited surgical workforce, distance to the hospital, and limited emergency transportation services are a few factors that need to be considered and investigated for quality improvement. In general, trauma in rural settings of LMICs has been a significant cause of increased morbidity and mortality. However, there is some evidence to suggest that systems-based interventions can lead to decreases in the mortality rates [19–20].

In our pediatric cohort, typhoid ileitis and intussusception were among the most common indications for laparotomy. Typhoid intestinal perforation can be fatal [12, 21]. However, recent public health initiatives, improved sanitation, and operative intervention have been credited for an overall decrease in the incidence and mortality associated with typhoid intestinal perforation in LMICs, including Ghana [22–24]. Intussusception had the highest mortality rate in our study at 20%. In contrast to high income countries (HICs), radiographic decompression is not frequently available, and thus, children require operative intervention. The estimated mortality rate associated with intussusception for children in LMICs ranges from 6–25% among those who undergo surgery, compared to <1% in HICs [21].

Importantly, patients with NHI had improved POMRs. Odds of perioperative survival was 60% higher in patients who had health insurance. In both adults and children, nearly 40% of patients did not have insurance despite a low annual premium of $5 per person, and with children automatically covered if both parents have insurance. Interestingly, approximately 55% of all Ghanaians were thought to be enrolled with NHI in 2009 [25]. This suggests that either the overall enrollment rate has stagnated or efforts to insure Ghanaians have not reached rural areas. Interventions aimed at improving NHI coverage could have an important impact on POMR in Ghana.

There are a number of limitations in our study. First, more research data points from across the country of Ghana are needed to draw conclusions about differences in urban and rural settings. Next, and perhaps most notably, is the inability to risk adjust the POMR due to lack of retrospectively available patient information. Ideally, factors including, but not limited to, American Society of Anesthesiologist physical status classification, wound classification, functional status, and age should be used [3]. Adjunct therapies, such as anti-secretory therapy in patients with peptic ulcer disease, were also not reliably recorded in the EMR preventing inclusion in this study. Study outcomes related to mortality were limited to inpatient mortality given inability of the EMR to reliably capture 30-day and 90-day mortality rates. Going forward, our aim is to improve documentation of factors necessary for risk adjustment at this institution. Due to the small sample size, the power of the study was also limiting. It is conceivable that factors included in our mortality model could become significant with larger numbers. Additionally, sample size likely impacted our analysis of the influence of referrals on POMR. Finally, extrapolation of our findings to other rural hospitals in Ghana and throughout sub-Saharan Africa should be done with caution as our data points and findings are drawn from the operative experience of a single surgeon.

**Conclusion**

POMR has become an important quality indicator within the expanding field of global surgery. Our study shows that the benefits of POMR investigation extend to a hospital and community level and can provide insights into opportunities for future quality improvement initiatives. Additionally, this study demonstrates that collaboration between a large university and a rural hospital can result in meaningful research and quality improvement initiatives.

**Competing Interests**

All authors declare no financial relationships with any organizations with interest in the submitted work.

**References**

1. Jamison DT, Breman JG, Measham AR, et al. Disease Control Priorities in Developing Countries. 2nd ed. Washington: World Bank Publications; 2006. Available at: https://openknowledge.worldbank.org/handle/10986/7242 (accessed March 10, 2019). DOI: https://doi.org/10.1596/978-0-8213-6179-5

2. Meara JG, Leather AJ, Hagander L, et al. Global surgery 2030: evidence and solutions for achieving health, welfare, and economic development. Lancet. 2015; 386(9993): 569–624. DOI: https://doi.org/10.1016/S0140-6736(15)60160-X

3. Watters DA, Hollands MJ, Gruen RL, et al. Perioperative mortality rate (POMR): a global indicator of access to safe surgery and anaesthesia. World J Surg. 2015; 39(4): 856–864. DOI: https://doi.org/10.1007/s00268-014-2638-4

4. Luboga S, Macfarlane SB, von Schreeb J, et al. Increasing access to surgical services in sub-saharan Africa: priorities for national and international agencies recommended by the Bellagio Essential Surgery Group. PLoS Med. 2009; 6(12): e1000200. DOI: https://doi.org/10.1371/journal.pmed.1000200

5. Ohene-Yeboah M. Acute surgical admissions for abdominal pain in adults in Kumasi, Ghana. ANZ J Surg. 2006; 76(10): 898–903. DOI: https://onlinelibrary.wiley.com/doi/10.1111/j.1445-2197.2006.03905.x

6. Ohene-Yeboah M, Dakubo JC, Boakye F, Naeeder SB. Penetrating abdominal injuries in adults seen at two teaching hospitals in Ghana. Ghana Med J. 2010; 44(3): 103–108. DOI: https://doi.org/10.4314/gmj.v44i3.68893

7. Abantanga FA, Nimako B, Amoah M. The range of abdominal surgical emergencies in children older than 1 year at the Komfo Anokye Teaching Hospital, Kumasi, Ghana. Ann Afr Med. 2009; 8(4): 236–242. DOI: https://doi.org/10.4103/1596-3519.59578

8. Dakubo JC, Naeeder SB, Clegg-Lamprey JN. Gastro-duodenal peptic ulcer perforation. East Afr J Med Surg Obstet Gynaecol. 2015; 39(4): 856–864.
Typhoid ileal perforation in children: Signs of increasing prevalence of Helicobacter pylori among patients at a corporate hospital in Ghana. *Ghana Med J*. 2015; 32(5): 389–396. DOI: https://doi.org/10.1002/bjs.9376

Osifo OD, Ogiemwonyi SO. Typhoid ileal perforation in children in Benin city. *Afr J Paediatr Surg*. 2010; 7(2): 96–100. DOI: https://doi.org/10.4103/0189-6725.62857

Ameh EA. Typhoid ileal perforation in children: A scourge in developing countries. *Ann Trop Paediatr*. 1999; 19(3): 267–272. DOI: https://doi.org/10.1080/02724939992356

Clegg-Lamptey JN, Hodasi WM, Dakubo JC. Typhoid ileal perforation in Ghana: A five-year retrospective study. *Trop Doct*. 2007; 37(4): 231–233. DOI: https://doi.org/10.1258/004947507782332784

Jehu-Appiah C, Aryeetey G, Spaan E, de Hoop T, Agyepong I, Baltussen R. Equity aspects of the national health insurance scheme in Ghana: Who is enrolling, who is not and why? *Soc Sci Med*. 2011; 72(2): 157–165. DOI: https://doi.org/10.1016/j.socscimed.2010.10.025

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