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Emergency-to-Elective Surgery Ratio as an Institutional Metric for Pediatric Surgical Access at a Tertiary Referral Hospital in Malawi

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Abstract

Purpose

The emergency-to-elective surgery ratio (E:e) is the number of emergency operations per 100 elective operations. We compared E:e for pediatric surgery at a single center with that at other centers and described variation in E:e by patient and referral characteristics.

Methods

We conducted a retrospective cross-sectional analysis of prospectively collected data on pediatric operations, excluding neurosurgery, at a tertiary referral center in Lilongwe, Malawi, from April 2023 to June 2024. E:e was calculated, stratified by age, and compared with published data.

Results

1205 operations across 57 diagnoses were performed. 66% (n = 793) were male, with a mean age of 3.1 years. 50% (n = 599) were transferred from another facility. 18% (n = 221) of operations were emergent, yielding an overall E:e ratio of 22.5, which is lower than historical data from many low- and middle-income countries (LMIC). E:e was higher for transferred patients (40 versus 9 for self-referred) and for neonates (≤ 28 days) (81.4 versus 12.3 for non-neonates).

Conclusion

Our overall E:e is lower than previously reported ratios. E:e may serve as a proxy for institutional pediatric surgical access, reflecting the capacity to deliver planned operative care despite ongoing emergency demand.

Introduction

Delivering timely, appropriate, and high-quality surgical care is a hallmark of a healthcare system's maturity [1]. Access to such care remains a major global health challenge, especially in low- and middle-income countries (LMICs), where more than five billion people lack timely access to surgical and anesthesia care [2]. In resource-limited settings, delays in accessing care often increase the burden of urgent and emergent surgical operations, contributing to preventable morbidity and mortality—especially among children [3]. Limited surgical capacity and workforce constraints further strain systems, reducing the ability to provide elective care [4, 5].

Assessing and addressing healthcare system capacity is critical to strengthening the delivery of surgical care. Global surgery indicators provide a standardized framework for assessing surgical systems, but

data availability and comparability limit their use in evaluating whether individual hospitals can meet local surgical needs [6, 7]. Various metrics, including surgical volume, perioperative mortality rates, and workforce density, have been proposed to assess surgical systems in LMICs [6]. However, these indicators often require extensive data infrastructure and may not capture hospital-level capacity. The Emergency-to-elective surgery ratio (E:e), defined as the number of emergency operations per 100 elective operations, has been proposed as a pragmatic proxy for evaluating surgical access and capacity, particularly in resource-constrained settings [8]. A high E:e may indicate that a healthcare system is overwhelmed by urgent or emergent operations and lacks the resources to provide timely elective care. Monitoring E:e trends over time may help identify facilities under strain and may inform targeted interventions or resource allocation to improve surgical access.

According to recent estimates, at least 11% of the global burden of disease is attributable to surgically treatable diseases. In children, the burden is even more striking, with up to 85% of children in low- and middle-income countries (LMIC) having a surgically treatable condition by age 15 [3]. In Malawi, population-based data suggest that approximately 26% of children are living with a condition that could be treated surgically, and that neonates have a 12-fold increase in in-hospital mortality compared with older children [9, 10]. Given the substantial pediatric surgical burden in Malawi, we sought to determine E:e in our resource-limited setting in Lilongwe and compare it with global ratios.

Material and Methods

Study Setting

This study was conducted at Kamuzu Central Hospital (KCH) in Lilongwe, Malawi, one of the country's four government-operated tertiary referral hospitals. KCH is the only tertiary hospital serving the central region, which has an estimated population of 7.5 million [11]. The hospital has approximately 800 beds, including 215 pediatric and 80 neonatal beds, and beds are often occupied by two patients [10]. A pediatric surgical registry was established in 2019 to systematically document all admissions to pediatric surgical services. Trained data clerks collect and enter the data directly into a Research Electronic Data Capture (REDCap) database. Surgical residents, attending physicians, and research fellows routinely review these entries for accuracy.

Study Population and Design

We conducted a retrospective cross-sectional analysis of pediatric surgical operations at KCH and compared our findings narratively with previously published E:e to contextualize them. We reported this study in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [12]. We included all recorded pediatric operations at KCH, except neurosurgery, among children from birth to 13 years from April 1, 2023, to June 30, 2024. The unit of analysis was the operation; if a patient underwent more than one operation during the study period, each operation was

counted separately. We collected demographic information, diagnoses, surgical interventions, clinical outcomes, and surgery classification (emergent versus elective). The primary outcome measure was the overall E:e. Emergency operations were identified using the urgency classification documented in the operative report when available. When the surgeon did not document an urgency classification, operating room staff categorized the operation as emergent or elective based on the surgical list on which the case was performed. Secondary outcomes included E:e stratified by transfer status, age categories, sex, readmissions, and specific diagnoses.

Sample size comprised all recorded eligible operations. Lost records could not be recovered or enumerated. Repeat operations were counted separately.

To contextualize our institutional E:e, we conducted a narrative literature review. Previously reported E:e values were identified from studies included in the prior work by Prin et al., which established E:e calculation as a surgical access metric, and from additional published institutional or national reports that provided sufficient emergency and elective operative counts for E:e calculation. These comparator studies were used solely for descriptive context. Because the included studies differed by country, hospital level, age group, surgical specialty mix, time period, and definition of emergency surgery, the reported comparisons were not intended to represent a pooled estimate or formal meta-analysis.

Data came from electronic records (Neotree for neonates only) and paper admission records. Transfers arrived from another facility; self-presenting patients came directly from home to the emergency department. Readmission was any subsequent admission for the same condition. Age groups were ≤ 28 days, 29 days to < 1 year, 1–3 years, and 4–13 years, using completed years for the latter groups.

Weekly meetings with clinicians and medically trained data clerks checked data quality. A physician research fellow audited a random 10% sample of records across 20 key fields using a standardized system. Accuracy across the checked fields was 95.94%; identified errors were corrected with the local clinical team.

Statistical Analysis

Data analyses were conducted using Stata 18.0. Univariate analyses were performed to evaluate the distributions of all variables. Categorical variables were summarized with counts and percentages. Continuous data were summarized as means and standard deviations (SDs) for normally distributed data or as medians and interquartile ranges (IQRs) for non-normally distributed data. E:e was calculated as [8]:

E:e = emergency operations / elective operations × 100

Missing values were excluded only from analyses requiring that variable. E:e was descriptive; no inferential or sensitivity analyses were performed.

Ethical Considerations

We obtained ethical approval from the National Health Sciences Research Committee (NHSRC) of Malawi (Protocol #19/10/2432) and the University of North Carolina Institutional Review Board (IRB no. 19-2413). All data were kept confidential and securely stored in the REDCap system, with access restricted to authorized personnel only. This study was exempt from the requirement for informed consent.

Use of artificial intelligence

ChatGPT (OpenAI) was used solely to assist with language editing of the manuscript; the authors retain full responsibility for its content.

Results

Among 1205 pediatric surgical operations performed between April 2023 and June 2024, the overall E:e was 22.5. The cohort's mean age was 3.1 years, and 18.3% of operations were emergent. Female patients accounted for 34.2% of the cohort and had a higher E:e (32.1) than males (18.0). Nearly half of patients (49.8%) were transferred from outside facilities; transfers had a markedly elevated E:e of 40, whereas self-presenting patients had a lower E:e of 9. Readmissions accounted for 15.4% of the sample and had a low E:e of 5.7, compared with first-time admissions, which had a higher E:e of 26.1 (Table 1).

Table 1
Operation characteristics and associated E:e.

Characteristics	N (%)	Emergent	E:e
Overall	1205	221	22.5
Female	412 (34.2)	100	32.1
Male	793 (65.8)	121	18.0
Age			
Neonate (birth to 28 days)	254 (21.1)	114	81.4
Infants (28 days to 1 year)	156 (12.9)	27	20.9
Toddlers (1–3 years)	387 (32.1)	31	8.7
Children (4–13 years)	399 (33.1)	45	12.7
Missing	9 (0.8)	4	—
Transferred	599 (49.8)	171	40.0
Self-Presented	606 (50.2)	50	9.0
Readmission	185 (15.4)	10	5.7
First Admission	1020 (84.6)	211	26.1

The most common diagnoses for emergency operations were gastroschisis, abscess, appendicitis, airway foreign body, intussusception, and anorectal malformations, whereas the most common elective diagnoses were inguinal hernia, Hirschsprung's disease, and undescended testicle (Fig. 1). Neonates had the highest emergency burden (E:e 81.4 versus 12.3 for overall known-age non-neonates), whereas children 1 to 3 years had the highest elective surgery burden (E:e 8.7), predominantly due to inguinal hernia repair (Fig. 2).

Age was missing for 9 operations (0.7%), including 4 emergencies; these remained in overall but not age-specific E:e. Sex, referral status, admission status, and urgency were complete.

The pediatric surgical E:e at KCH was lower than the median E:e reported for pediatric surgical populations in other LMICs. In this narrative comparison, the median reported pediatric LMIC E:e was 91.4; however, this value is intended only to provide descriptive context, as the included studies differed substantially in case mix, setting, and emergency classification [13–16]. Hospitals in Uganda and Ethiopia reported E:e of 133.1 and 114.1, respectively. For contextual comparison, studies including all surgical operations, rather than pediatric operations alone, also reported higher E:e values in many LMIC settings (median 98.5; IQR 62.9–156.9), including historical Malawi cohorts with E:e of 75.9 and 115.2 [8, 17–24]. In contrast, high-income countries (HICs) like the United States and Australia had lower reported E:e (median 14.9; IQR 14.6–16.6) (Table 2) (Fig. 3) [25–29].

Table 2
Previously reported E:e from other institutions.

Pediatric surgery KCH	**Time period**	**Emergent**	**Elective**	**E:e**	**Median**	**IQR**
	2023–2024	**221**	**984**	**22.5**		
Pediatric surgery LMIC					**91.4**	67.0–118.8
India (Hospital) [13]	2021	59	96	**61.5**		
Uganda (Hospital) [14]	2015–2017	571	429	**133.1**		
Ethiopia (Hospital) [15]	2019	648	942	**68.8**		
Ethiopia (Hospital) [16]	2023	624	547	**114.1**		
HIC All surgery					**14.9**	14.6–16.6
USA (National) NSQIP [25]	2005–2008	67,445	406,174	**16.6**		
USA (National) NACOR [26]	2010–2014	82,324	2,647,035	**3.1**		
Australia (National) [27]	2013–2014	304,741	2,080,152	**14.7**		
Australia (Hospital) [28]	2008–2018	25,041	70,192	**35.7**		
Japan (Hospital) [29]	2010–2014	2,304	15,421	**14.9**		
LMIC all surgery					**98.5**	62.9–156.9
Malawi (Hospital) [8]	2004–2007	5,243	6,908	**75.9**		
Malawi (Hospital) [8]	2015–2016	2,553	2,216	**115.2**		
Mozambique (Hospital) [8, 17]	2015	88	30	**293.3**		

**US (United States), NSQIP (National Surgical Quality Improvement Program), NACOR (National Anesthesia Clinical Outcome Registry), AU (Australia), and MSF (Médecins Sans Frontières), DRC Democratic Republic of the Congo), CAR (Central African Republic), SS (South Sudan).*

Pediatric surgery KCH	Time period	Emergent	Elective	E:e	Median	IQR
	2023–2024	**221**	**984**	**22.5**		
Sierra Leone (Hospital) [8, 18]	2012–2013	8	496	**1.6**		
Uganda (Hospital) [8, 19]	2011	1,581	2,701	**58.5**		
Uganda (Hospital) [8, 20]	2008–2011	810	5,536	**14.6**		
South Africa (Regional) [21]	2015	7,777	4,580	**169.8**		
South Africa (Hospital) [8, 22]	2014	2,120	1,795	**118.1**		
MSF (DRC, CAR, SS) [8, 23]	2011–2013	7,803	1,400	**557.4**		
Brazil (Hospital) [8, 24]	2011–2012	3,760	4,600	**81.7**		

**US (United States), NSQIP (National Surgical Quality Improvement Program), NACOR (National Anesthesia Clinical Outcome Registry), AU (Australia), and MSF (Médecins Sans Frontières), DRC Democratic Republic of the Congo), CAR (Central African Republic), SS (South Sudan).*

Discussion

The overall E:e at our single institution was 22.5, with higher ratios observed in operations among female patients, transferred patients, and first-time admissions. The higher E:e for operations among female patients likely reflects differences in case mix rather than sex-based differences in access; in particular, the predominance of elective inguinal hernia repair and orchidopexy among male patients likely lowered E:e among males. The higher E:e for operations among transferred patients suggests that referral pathways may concentrate the emergency operative burden at KCH.

Neonates had the highest emergency burden, whereas children aged 1–3 years had the highest elective surgery burden. The most common diagnoses for emergency operations were gastroschisis, abscess, appendicitis, airway foreign body, intussusception, and anorectal malformations. The most common elective diagnoses were inguinal hernia, Hirschsprung's disease, and undescended testicle. Compared with published pediatric surgical cohorts from other LMIC settings, KCH had a lower E:e. Broader all-surgery datasets from HICs, such as the United States and Australia, generally report lower ratios, though these comparisons should be interpreted with caution because they include adult and pediatric operations across different surgical systems.

These data build on the growing literature suggesting that the balance of elective and emergent operations at a hospital can serve as a practical indicator of operative case mix and potential capacity constraints [8, 14]. In Uganda, Grabski et. al. found that emergency intestinal diversions for congenital colorectal malformations (anorectal malformations and Hirschsprung's disease) occurred three times as often as elective definitive repairs, and 30% of inguinal hernias were incarcerated or strangulated at the time of repair. These emergencies consumed most of the surgical resources and led to a further backlog of the elective operations [14]. Overall, emergency and urgent pediatric surgical operations account for a disproportionate share of operative resources in LMICs, underscoring the need to expand pediatric surgical capacity and to use E:e as an actionable institutional metric that may reflect backlog, unmet need, and constraints in elective operative capacity.

Increasing elective surgical capacity can ease the burden of emergency procedures by addressing treatable conditions before they become life-threatening, thereby optimizing outcomes. Haider et al. found that, in the United States in 2001 and 2010, if 10% of emergency procedures had been performed electively, the cost-benefit would have been nearly $1 billion [30]. A study by the National Institute for Health and Care Research in the UK found that complications are higher with emergent than with elective hernia surgery across 83 countries, and that the rate of emergent surgery increases in low-income countries [31]. Conversely, if a service is overloaded with emergency operations, elective procedures may be delayed or canceled, and some parents may choose not to re-present after repeated cancellations. This creates a vicious cycle in which low capacity leads to missed elective procedures, which then become emergent, further diminishing elective capacity.

E:e may also highlight disparities in surgical access. In low-resource settings, surgical care tends to be more reactive than proactive. In 2020, Langlois et al. found that, despite the growing burden of non-communicable diseases, many low- and middle-income countries lacked funding for preventive services [32]. By providing an accessible institutional measure of surgical capacity, E:e may inform resource allocation decisions when interpreted alongside other indicators [33]. For instance, training programs that increase the number of qualified surgeons can shift the balance from emergency to elective operations, thereby enhancing overall quality of care [34, 35].

Further improvements in healthcare infrastructure, such as dedicated pediatric operating rooms and specialized staff, have been associated with higher elective surgery rates [36][37]. The implementation of surgical waitlists has also been shown to positively influence E:e [38]. The lower E:e at our institution compared with several other LMIC institutions may reflect, in part, several local factors: the presence of a pediatric surgery training program may have increased the availability of the operative workforce, a pediatric operating room with dedicated staff may have improved elective operative flow; and the implementation of a surgical waitlist may have supported more organized management of elective cases. These institutional improvements align with the Lancet global surgery recommendations for building surgical care capacity [6].

This study demonstrated a high proportion of emergency operations in neonates. This aligns with the published literature and underscores the need for timely surgical interventions in this vulnerable group [39–41]. The high concentration of elective operations among older children in this study is driven by elective hernia repairs, indicating that many patients can be managed electively in this setting, thereby reducing the need for emergency interventions [42].

The study had several limitations. Emergency and elective operations were classified based on surgeon documentation when available and surgical list designation when urgency was not documented; however, the registry did not apply a standardized clinical urgency scale. Semi-urgent operations may therefore have been classified differently by surgeons, operating room staff, or over time. In addition, there is no uniform definition of emergency versus elective surgery across the literature, limiting direct comparisons between institutions and health systems.

Additionally, although E:e is attractive because it can be calculated from routinely collected operative data, it should not be interpreted as a stand-alone measure of surgical access or system capacity. A low E:e may reflect strong elective operative capacity, but it may also reflect under-referral of emergency conditions, deaths before arrival, exclusion of emergency-heavy specialties, differences in case mix, or variation in classification practices. Conversely, a high E:e may reflect limited elective capacity or the role of a referral center in receiving complex emergency cases. E:e is therefore best understood as an institutional signal that requires interpretation within the local surgical ecosystem.

Common pediatric surgical conditions, such as inguinal hernias, are typically stable but can lead to serious complications if treatment is delayed. They are sensitive to surgical capacity and may reflect system performance well [42]. However, other procedures may not be equally sensitive to surgical capacity. Trauma, by definition, is inherently emergent and largely independent of elective surgical availability. Neonatal surgical conditions, while frequently emergent, exist along a spectrum; some require immediate intervention, whereas others could be managed electively if timely diagnosis, referral, and operative capacity were available [6, 43].

Missing ages may affect age-specific E:e. Misclassifying emergency operations as elective lowers E:e, while the reverse raises it. The magnitude of this bias is minimal given only 0.7% were missing.

Local clinical review helped address contextual bias from international researchers. Lost records could not be recovered, and their effect was unknown.

While we calculated our E:e across all procedures to ensure comparable results across settings, we acknowledge that a baseline prevalence of emergent operations persists despite advances in surgical capacity. Finally, the study was conducted at a single institution, which may limit its applicability to other settings. Expanding the research to include multiple institutions across different regions would provide a more comprehensive understanding of the applicability of E:e in various healthcare settings and support the validation of E:e as a comparable institutional metric for assessing surgical access and capacity.

Conclusion

Neonates had the highest burden of emergency operations in this study of pediatric surgical care at a tertiary referral hospital in Malawi, underscoring the need for targeted resource allocation to this vulnerable group. E:e may serve as a practical institutional proxy for pediatric surgical access in resource-limited settings by reflecting the balance between urgent operative demand and the capacity to deliver planned elective care. In settings where direct measures of surgical capacity, unmet need, and operative backlog are difficult to obtain, E:e may help hospitals monitor trends, identify services under strain, and inform investments in workforce, infrastructure, and elective surgical systems. However, E:e should be interpreted in relation to local referral patterns, case mix, and disease burden, and should be used alongside other indicators such as perioperative outcomes, waiting times, cancellations, length of stay, and complication rates. Further multi-institutional work is needed to determine how E:e correlates with pediatric surgical capacity, access, and quality across different health systems.

Declarations

Funding

No funding was received for this study. The registry is maintained by the Malawi Surgical Institute, an NGO under Project Malawi affiliated with the University of North Carolina.

Conflicts of interest:

All authors declare no conflicts of interest.

Ethics approval:

Approved by the National Health Sciences Research Committee of Malawi (Protocol #19/10/2432) and the University of North Carolina Institutional Review Board (IRB no. 19-2413).

Informed consent:

This study was exempt from the requirement for informed consent.

Author Contribution

X.L. conceived and designed the study, conducted the investigation, curated and analyzed the data, prepared the figures, coordinated the project, and wrote the original draft. A.C. and B.N. contributed to study conception and design and supervised the project. L.L.W. contributed to study conception and

design, investigation, data curation, and supervision. B.T., W.P., J.B., B.A., S.M., and A.M. contributed to study conception and investigation. All authors reviewed and edited the manuscript and approved the final version.

Data Availability

The data analyzed in this study were obtained from the Kamuzu Central Hospital pediatric surgical registry. The operation-level records are not publicly available because access to the registry is restricted to protect patient confidentiality. Aggregate data supporting the findings are presented in Tables 1 and 2.

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Figures

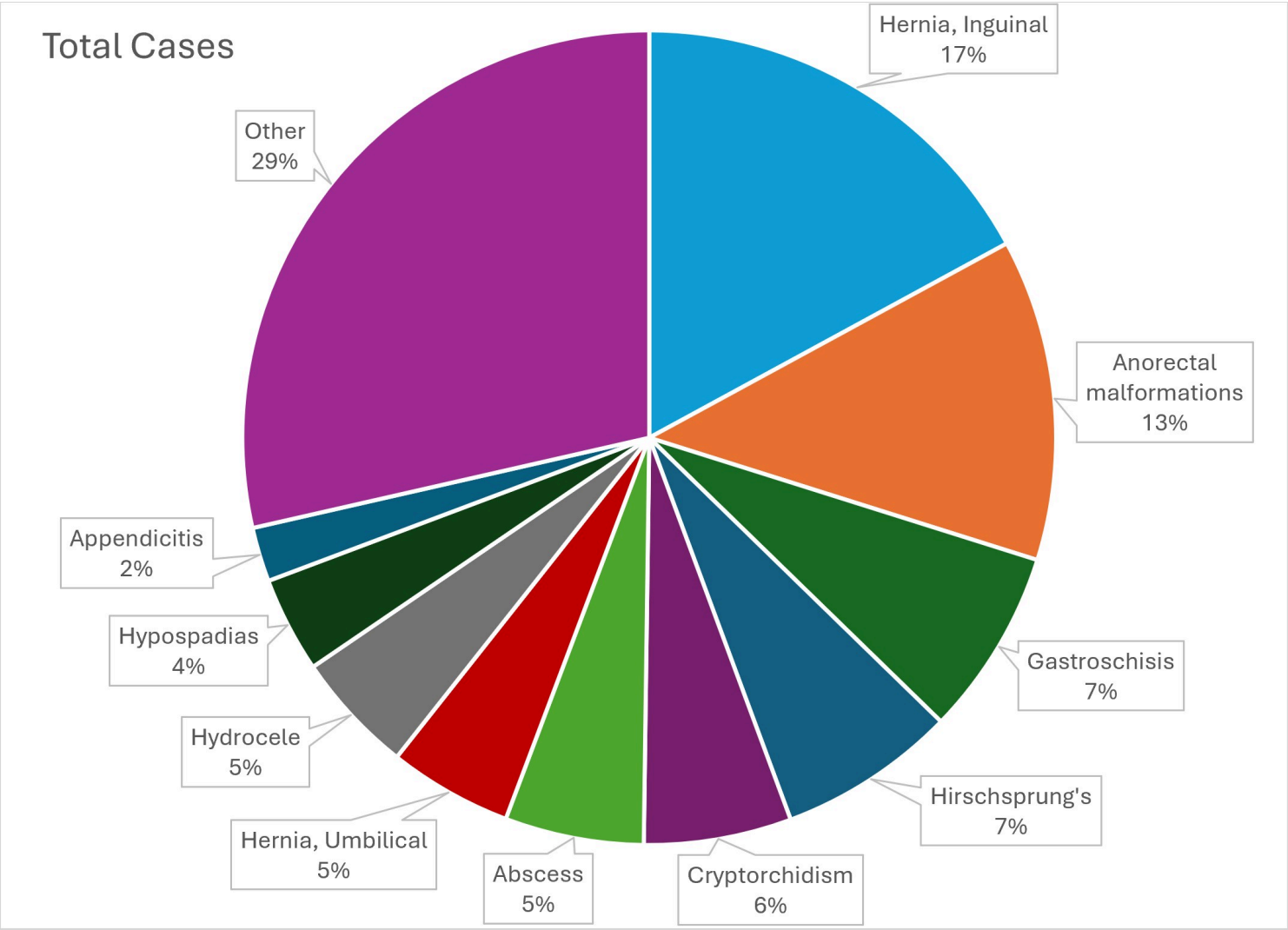


Figure 1

The ten most frequent diagnoses

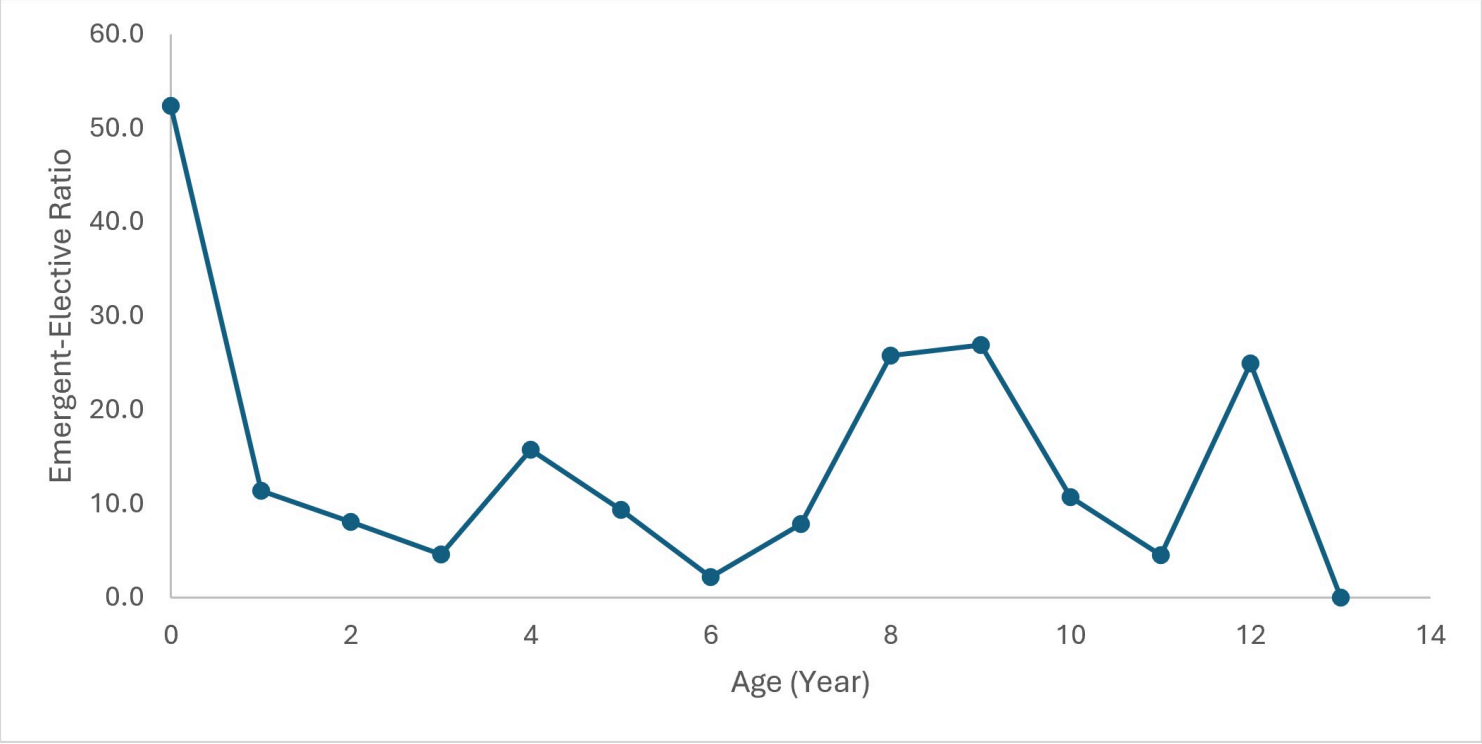


Figure 2

E:e by age in years. Patients under 1 year are shown at age 0; neonatal and infant subgroup E:e values are reported separately in Table 1

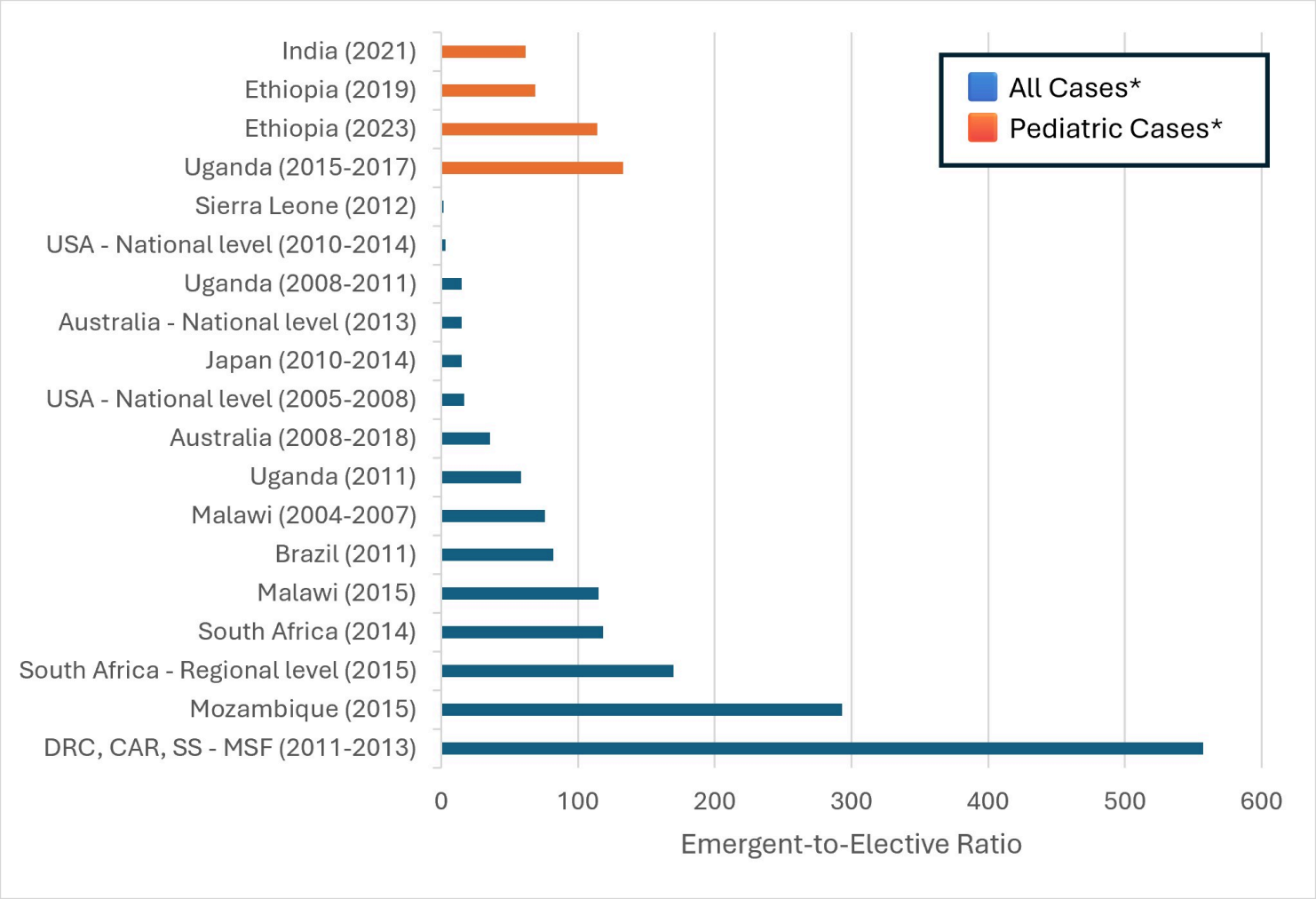


Figure 3

E:e by country. NSQIP, National Surgical Quality Improvement Program; NACOR, National Anesthesia Clinical Outcomes Registry; MSF, Médecins Sans Frontières; DRC, Democratic Republic of the Congo; CAR, Central African Republic; SS, South Sudan. Pediatric-only and all-surgery studies are shown together for descriptive context and are not intended as direct case-mix-adjusted comparisons