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Predicting In-hospital Mortality of Pediatric Surgical Admissions in Central Malawi

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A B S T R A C T

Background: Kamuzu Central Hospital (KCH), a tertiary care facility, serves as 1 of 2 pediatric surgical centers in Malawi, a resource limited country in southeastern Africa. We sought to understand the impact of clinical and access-related factors on in-hospital mortality at KCH.
Methods: Pediatric surgical admissions (<15 years) to KCH from April 1-December 1, 2023, were retrospectively analyzed. Patients were stratified as neonatal (admitted in the first 30 days of life) and non-neonatal. ArcGIS was used to calculate approximate distances traveled to care and to create district-level choropleth maps. Multivariate logistic regression analyses were conducted to identify relevant patient and pre-admission characteristics predictive of in-hospital mortality.
Results: Of 1044 pediatric surgical admissions, 211 (20.2 %) were neonatal, and 833 (79.8 %) were non-neonatal. In-hospital mortality was 23.8 % (n = 50) for neonatal admissions and 2 % (n = 17) for non-neonatal admissions. Increasing distance from home to KCH (OR = 0.22, p = 0.01) and increasing age (OR = 0.93, p < 0.01) conferred a protective effect on in-hospital mortality for neonatal admissions. For non-neonatal patients, readmission (OR = 4.69, p = 0.02) and high level of care on admission (OR = 14.79, p < 0.001) increased the odds of mortality. A distance effect was not seen in the non-neonatal population.
Conclusions: There is a 12-fold increase of in-hospital mortality among admitted neonates with surgical conditions compared to older children. A protective effect of distance in this group may represent the natural selection of healthier neonates being able to travel from farther distances successfully. Older children who were previously admitted or required higher levels of care were at increased risk of death.

1. Introduction

An estimated 2 million children are living with a surgically correctable condition in Malawi, a country of 20 million people in southeastern Africa [1]. Access to surgical care for children remains limited in Malawi due to limited geographic accessibility, constrained workforce numbers, financial burden on the existing health system and individual patients, and difficulties in longitudinal patient management [2–4]. Over the past decade, there has been an expansion of the pediatric surgical workforce in Malawi [2] and the development of dedicated pediatric surgical operating

Abbreviations: KCH, Kamuzu Central Hospital; km, kilometer; QECH, Queen Elizabeth Central Hospital; ARM, Anorectal malformation; UDT, undescended testes; SCT, Sacrococcygeal teratoma; NSTI, Necrotizing soft tissue infection; UGIB, Upper gastrointestinal bleed; PUV, Posterior urethral valves; DSD, Disorders of sex development; EC, Enterocutaneous; NEC, Necrotizing enterocolitis.

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rooms has facilitated training and increased operative volume [5]. Despite advances in the workforce and infrastructure, there is little publicly available information describing the geographical accessibility of these services and existing reports of in-hospital outcomes now pre-date the changes that have occurred over the past decade [2].

Children who can successfully access surgical care in Malawi have been reported to have in-hospital mortality rates ranging from 3 % up to 100 % [6,7]. Decreasing neonatal mortality and increasing access to pediatric surgical care worldwide are tenets of the sustainable development goals (SDGs) [8]. In an effort to achieve these benchmarks and provide quality healthcare for all children, detailing the epidemiology and geographic access to care in low-resource settings is imperative. Health facility access and the impact of distance to care on in-hospital mortality have yet to be documented in the pediatric population served by surgical referral centers in Malawi. We, therefore, sought to describe the pediatric patient population seen by surgical services at a tertiary facility in central Malawi, outline an estimated catchment area and geographic trends for in-hospital mortality, and identify predictors of in-hospital mortality.

2. Methods

2.1. Study setting and data source

Kamuzu Central Hospital (KCH) is a tertiary healthcare facility in Lilongwe, central Malawi that serves as one of two facilities in Malawi that provide pediatric surgical care. The hospital includes 215 pediatric beds, including 6 pediatric high-dependency unit beds and 80 neonatal beds [9,10]. KCH's pediatric surgical service has established a registry of all hospital admissions. Data are collected on admitted patients by data clerks and entered directly into a REDCap database using tablets [11,12]. Data include demographic information and clinical information regarding initial presentation, transfers of care, laboratory and imaging studies, operative management, and final patient disposition. The clinical staff routinely reviews data for accuracy.

2.2. Study population and design

We conducted a retrospective, cross-sectional analysis of all pediatric admissions to surgical services at KCH from April 1 to December 1, 2023. We included children <15 years of age. Admissions to pediatric general surgery, ENT, orthopedics, plastic surgery, and urology services were included. All trauma admissions were excluded.

2.3. Patient characteristics and outcomes

We examined demographic (age, sex, home traditional authority/district) and clinical (prematurity, readmission status, admission diagnosis, operative management) variables. Patients were categorized into those with neonatal surgical pathologies (admitted within 30 days of life) and those with non-neonatal surgical pathologies (admitted after 30 days of life). The level of care on admission was categorized as high or low by the admission unit based on consensus by the clinical team (Supplementary Fig. 1). Traditional authority (TA), district, and region boundaries for Malawi were delineated based on 2018 shapefiles developed by the National Statistics Office of Malawi [13]. Distances between the patient's home residence and KCH were estimated based on TA centroid locations in ArcGIS Pro v3.3. For instances in which a patient's TA location was unclear or unavailable, their home district centroid was instead used to calculate the distance to KCH. Detailed data on patient travel to all pretransfer healthcare sites were not available. The primary outcome was defined as in-hospital mortality. Secondary outcomes included in-hospital mortality incidence rates by district.

2.4. Statistical analysis

Descriptive statistics were calculated for the entire population. Chi-square tests were used to compare demographics between neonatal and non-neonatal admissions. Multivariable logistic regression was used to predict patient characteristics associated with in-hospital mortality in the neonatal and non-neonatal populations. Mode of transportation was not included as a possible predictive factor in multivariable regression due to the strong correlation between pre-admission location and mode of transport (ex. 80.4 % of overall pediatric surgical admissions that arrived to KCH via ambulance presented from a district hospital). Age and distance were modeled as continuous variables. All statistical tests were two-sided, with a significance level set at $p < 0.05$. All analyses were performed using Stata version 18.0 (College Station, TX). ArcGIS Pro v3.3 was used to build choropleths for neonatal and non-neonatal admissions and deaths per 100 admissions by district. Ethical board approval was obtained by the National Health Science Research Committee of Malawi and the University of North Carolina Institutional Review Board. The requirement for consent in study participation was waived.

3. Results

3.1. Patient characteristics

A total of 1044 patients were admitted to a pediatric surgical service at KCH from April through November 2023. Two-hundred and eleven (20.2 %) of these were neonatal admissions, and 833 (79.8 %) were non-neonatal admissions. The median age of admitted neonates was 3 days (IQR = 1 to 16), and 107 (51.0 %) were female (Table 1). Of all neonatal admits, 30.3 % had gastroschisis, 17.5 % had Hirschsprung's disease (HD), and 9.5 % had abscesses (Table 1). The median age for non-neonatal admissions was 3 years (IQR = 1.2 to 6), and 271 (32.6 %) were female (Table 1). Of all non-neonatal admits, 13.9 % had inguinal hernias, 13.2 % had other diagnoses, and 10.0 % had HD (Table 1). Neonatal admissions were significantly more likely to be female and non-neonatal admissions were more likely to be male ($p < 0.001$). The spectrum of admissions diagnoses for each population was also significantly different (<0.001). Notably, some congenital diseases - anorectal malformation (n = 50, 6 %), posterior urethral valves (n = 4, 0.5 %), disorders of sex development bladder exstrophy (n = 3, 0.4 %), intestinal atresia (n = 2, 0.2 %), tracheoesophageal anomalies (n = 2, 0.2 %), and gastroschisis (n = 1, 0.1 %) - presented for admission after 30 days of life.

Neonatal admissions were more likely to be premature at birth than non-neonatal admissions (37.3 % vs. 2.2 %, $p < 0.001$) (Table 1). Neonatal admissions were less likely to be readmissions than non-neonatal admissions (4.3 % vs. 17.5 %, $p < 0.001$). Most neonatal admissions were admitted to high levels of care (n = 180, 85.3 %). The majority of non-neonatal admissions (n = 658, 79.0 %) were admitted to low levels of care. The variation in level of care on admissions between neonates and non-neonates was significantly different ($p < 0.001$). Neonatal admissions were less likely to be operatively managed than non-neonatal admissions (54.8 % vs. 66.6 %, $p = 0.002$). The most common pre-admission location was district hospitals (n = 22, 10.5 %) for neonates and home (n = 462, 55.5 %) for non-neonates. The distribution of pre-admission location was significantly different between neonatal and non-neonatal

Table 1
Patient characteristics. Table depicting patient characteristics for pediatric patients admitted to surgical services at KCH from Apr—Nov 2023 by admission type (n = 1044). P-values were calculated using Mann-Whitney-U or Chi-square testing.

	Overall (n = 1044)	Neonatal admissions (n = 211)		Non-neonatal admissions (n = 833)		P-value
Age (median, IQR)	2 years (0.33—5)	3 days (1—16)		3 years (1.2—6)		<0.001
Sex, n (%)[a]						<0.001
Female	378 (36.3)	107 (51.0)		271 (32.6)		
Male	664 (63.7)	103 (49.0)		561 (67.4)		
Admission diagnosis, n (%)	–	Gastroschisis	64 (30.3)	Reducible inguinal hernia	116 (13.9)	<0.001
		Hirschsprungs disease	37 (17.5)	Other	110 (13.2)	
		Abscess	20 (9.5)	Hirschsprungs disease	83 (10.0)	
		Omphalocele	16 (7.6)	Abscess	64 (7.7)	
		Other	15 (7.1)	ARM	50 (6.0)	
		ARM	12 (5.7)	Hypospadias	46 (5.5)	
		Bowel obstruction	8 (3.8)	UDT	28 (3.4)	
		Multiple	8 (3.8)	Umbilical hernia	26 (3.1)	
		Reducible inguinal hernia	4 (1.9)	Airway foreign body	24 (2.9)	
		Intestinal atresia	4 (1.9)	Multiple	24 (2.9)	
		SCT	4 (1.9)	Bowel obstruction	21 (2.5)	
		Cyst	3 (1.4)	Hernia, other	20 (2.4)	
		Cellulitis	2 (1.0)	Foreign body ingestion	20 (2.4)	
		Ileus	2 (1.0)	Cyst	18 (2.2)	
		Abdominal distension	1 (0.5)	Hydrocele	17 (2.0)	
		Bladder exstrophy	1 (0.5)	Cellulitis	16 (1.9)	
		Cloacal exstrophy	1 (0.5)	Adenotonsillar hypertrophy	14 (1.7)	
		Duodenal obstruction	1 (0.5)	Wilms tumor	11 (1.3)	
		Tracheoesophageal anomaly	1 (0.5)	Rectal prolapse	9 (1.1)	
		Gangrene	1 (0.5)	Acute appendicitis	8 (1.0)	
		Hydrocele	1 (0.5)	Soft tissue mass	8 (1.0)	
		Hypospadias	1 (0.5)	Abdominal mass	6 (0.7)	
		Jejunal/Ileal atresia	1 (0.5)	Empyema	6 (0.7)	
		NSTI	1 (0.5)	Abscess, perineal or buttock	5 (0.6)	
		PUV	1 (0.5)	Pressure sores	5 (0.6)	
		Pyloric stenosis	1 (0.5)	UGIB	5 (0.6)	
				Neuroblastoma	4 (0.5)	
				Stoma reversal	4 (0.5)	
				PUV	4 (0.5)	
				Ascites	3 (0.4)	
				DSD	3 (0.4)	
				Fistula, other	3 (0.4)	
				Hemangioma/Lymphan-gioma	3 (0.4)	
				Irreducible inguinal hernia	3 (0.4)	
				Irreducible umbilical hernia	3 (0.4)	
				Ileal perforation	3 (0.4)	
				Jaundice	3 (0.4)	
				Wound infection	3 (0.4)	
				Peritonitis	2 (0.2)	
				Bladder exstrophy	2 (0.2)	
				Ileus	2 (0.2)	
				Intestinal atresia	2 (0.2)	
				Intussusception	2 (0.2)	
				Pyloric stenosis	2 (0.2)	
				Rhabdomyosarcoma	2 (0.2)	
				SCT	2 (0.2)	
				Tracheoesophageal anomalies	2 (0.2)	
				Tumor, other	2 (0.2)	
				Esophageal achalasia	1 (0.1)	
				Chronic abdominal pain	1 (0.1)	
				Appendiceal abscess	1 (0.1)	
				Cholelithiasis/cholecystitis	1 (0.1)	
				Cloacal exstrophy	1 (0.1)	
				EC abdominal fistula	1 (0.1)	
				Vaginal fistula	1 (0.1)	
				Gangrene	1 (0.1)	
				Gastroschisis	1 (0.1)	
				Thyroglossal or branchial cyst	1 (0.1)	
				Phimosis	1 (0.1)	
				Rectal stenosis	1 (0.1)	
				Testicular torsion	1 (0.1)	
				Intestinal volvulus	1 (0.1)	
Premature at birth, n (%)[b]	96 (9.2)	78 (37.3)		18 (2.2)		<0.001
Readmission, n (%)	155 (14.9)	9 (4.3)		146 (17.5)		<0.001
Level of care on admission, n (%)						<0.001
Low	678 (64.9)	20 (9.5)		658 (79.0)		
High	237 (22.7)	180 (85.3)		57 (6.8)		
Missing	129 (12.4)	11 (5.2)		118 (14.2)		

(*continued on next page*)

Table 1 (*continued*)

	Overall (n = 1044)	Neonatal admissions (n = 211)	Non-neonatal admissions (n = 833)	P-value
Operative management, n (%)[c]	647 (64.3)	108 (54.8)	539 (66.6)	0.002
Pre-admission location, n (%)[a]				<0.001
Home	484 (46.5)	22 (10.5)	462 (55.5)	
Tertiary hospital	29 (2.8)	1 (0.5)	28 (3.4)	
District hospital	300 (28.8)	108 (51.4)	192 (23.1)	
Health center	144 (13.8)	51 (24.3)	93 (11.2)	
Private clinic/hospital	85 (8.2)	28 (13.3)	57 (6.9)	
Distance to KCH from home residence, in km (median, IQR)[d]	26.6 (11.7–69.9)	38.3 (11.7–76.8)	26.6 (11.7–69.9)	0.02
Mode of transport, n (%)[e]				<0.001
Ambulance	391 (37.5)	170 (82.5)	221 (26.9)	
Minibus, bus, lorry, motorcycle, tuk Tuk, taxi	605 (58.9)	31 (15.0)	574 (69.9)	
Private vehicle	26 (2.5)	5 (2.4)	21 (2.6)	
Walked	5 (0.5)	–	5 (0.6)	
In-hospital deaths, n (%)[f]	67 (6.4)	50 (23.8)	17 (2.1)	<0.001

IQR = interquartile range. ARM = Anorectal malformation. UDT = undescended testes. SCT= Sacrococcygeal teratoma. NSTI=Necrotizing soft tissue infection. UGIB=Upper gastrointestinal bleed. PUV=Posterior urethral valves. DSD = Disorders of sex development. EC = Enterocutaneous. NEC=Necrotizing enterocolitis. Cell value % is from column totals.

[a] Missing 2.
[b] Missing 3.
[c] Missing 38.
[d] Missing 13.
[e] Missing 17.
[f] Missing 4.

admissions ($p < 0.001$) (Table 1). Neonates traveled longer distances than non-neonates to seek care at KCH (median 38.3 km vs. 26.6 km, $p = 0.02$). Most neonates arrived to KCH via ambulance (n = 170, 82.5 %) and most non-neonates arrived to KCH via minibus, bus, lorry, motorcycle, tuk tuk or taxi (n = 574, 69.9 %).

3.2. *In-hospital mortality of pediatric surgical admissions*

There were 67 deaths over the study period (6.4 %). Neonates had higher in-hospital mortality than non-neonates during admission to KCH (23.8 % vs 2.1 %, $p < 0.001$) (Table 1). When predicting mortality for neonatal admissions by age, sex, prematurity, readmission status, care level on admission, operative management, pre-admission location, and distance from home to KCH, increasing distance from home to KCH (OR = 0.22, $p = 0.01$) and increasing age (OR = 0.93, p=<0.01) decreased odds of in-hospital mortality (Fig. 1A).

For non-neonatal admissions, readmission to KCH predicted higher mortality (OR = 4.7, $p = 0.02$) (Fig. 1B). Patients admitted to a high level of care (OR = 14.79, $p < 0.001$) and those missing documentation of admission level of care (OR = 6.88, $p < 0.01$) had higher odds of in-hospital mortality in comparison to their counterparts admitted to a low level of care (Fig. 1B). A distance effect on mortality was not observed in this population.

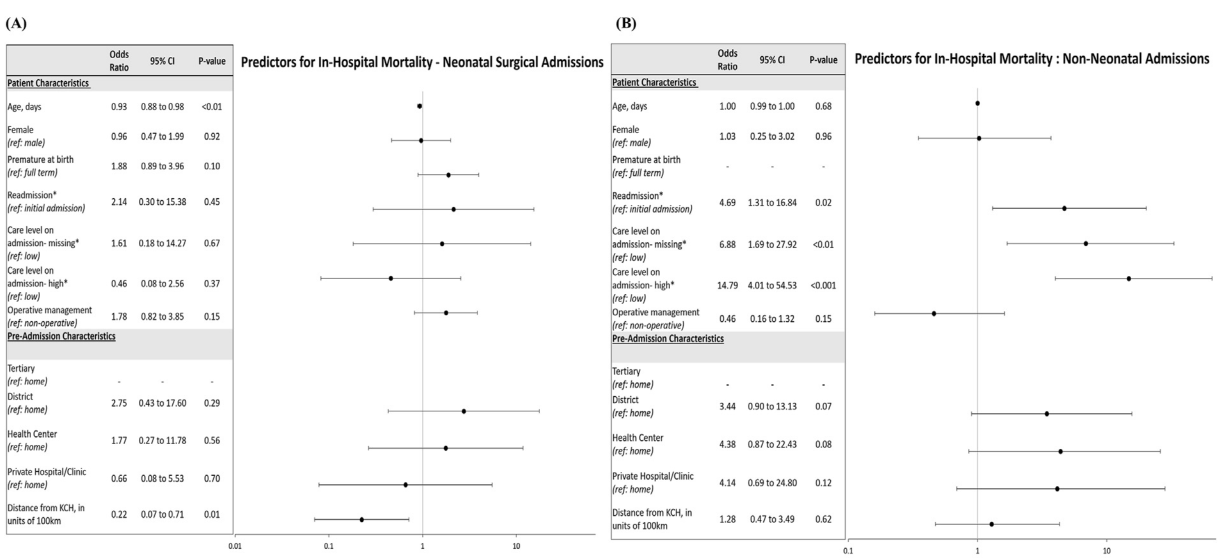

Fig. 1. Predictors of mortality for pediatric admissions to surgical services. Multivariable regression analysis of mortality by age, sex, prematurity, readmission, level of care on admission, operative management, pre-admission location, and distance to KCH for (**A**) neonatal diagnoses and (**B**) non-neonatal diagnoses. (**A**) 193 observations were used. The model omitted the tertiary hospital pre-admission location (n=1) due to the perfect survival prediction. (**B**) 791 observations were used. Tertiary hospital pre-admission location (n=26) and prematurity at birth (n=17) were omitted from the model due to predicting survival perfectly. *significant p-value.

The majority of neonatal deaths were in patients with gastroschisis (n = 31, 62 %), while non-neonatal deaths most commonly occurred in patients with bowel obstructions (n = 3, 17.6 %) (Fig. 2).

3.3. Geographic distribution of pediatric surgical admissions and in-hospital mortality

Patients presenting with neonatal surgical disease to KCH were predominantly from the central region of Malawi. There were very few admissions from the southern region, as these patients are likely to present for care at Queen Elizabeth Central Hospital (QECH) in Blantyre. There were few neonatal surgical admissions, ranging from 0 to 3 patients, from districts in the northern region (Fig. 3A). Lilongwe district had a relatively lower mortality rate of approximately 25.9 %, whereas Salima district has a mortality rate of approximately 57.1 % for neonates (Fig. 3B). All of the northern region districts had 0 % in-hospital mortality (Figs. 3A and B).

The geographic distribution of non-neonatal admissions to KCH was similar to that of neonates in the central region. Most of KCH's catchment area lies in immediate neighboring districts to Lilongwe. A similar pattern of a dearth of admissions from the southern region is reflected in non-neonates and neonates (Figs. 4A and 3A, respectively). There are increased admissions from the northern region, 1 to 13 patients per district for non-neonates compared to neonates (Figs. 4A and 3A, respectively).

Salima (57.1 deaths per 100 admissions), Ntchisi (33.3 deaths per 100 admissions), and Dowa (28.6 deaths per 100 admissions) districts had the highest in-hospital mortality for neonatal admissions. Districts in the periphery of the central region such as, Kasungu (4.2 deaths per 100 admissions), Dowa (4.1 deaths per 100 admissions), Nkhotakota (4.2 deaths per 100 admissions) and Ntcheu (4.3 deaths per 100 admissions) had the highest in-hospital mortality for non-neonatal admissions (Fig. 4B).

4. Discussion

This retrospective analysis of 8 months of pediatric surgical admission data showed that neonatal and non-neonatal surgical admissions are fundamentally different populations by age, sex, diagnoses, prematurity at birth, readmission status, level of care on admission, operative management, pre-admission location, and in-hospital mortality. Neonates are more likely to require higher level of care on admission, however it should be noted that high level of care in this study was designated in the context of available wards providing care to neonates. Several surgical conditions that are considered congenital and usually identified in the prenatal or neonatal period in high-resource settings (e.g. ARM, PUV, DSD, SCT, tracheoesophageal anomalies, bladder exstrophy, etc.) presented later in life in the studied population. Given the relatively low incidence of in-hospital mortality for the non-neonatal population, it is difficult to infer trends in survival across similar diagnoses based on age of admission. Distance and age are significant predictors of decreased in-hospital mortality when controlling for predictive variables within the neonatal admissions population. This counterintuitive finding of increasing distance to care being protective against mortality may allude to a gap in available data for pre-admission mortality for neonatal surgical pathologies in the community and outside facility setting or varying effects of distance

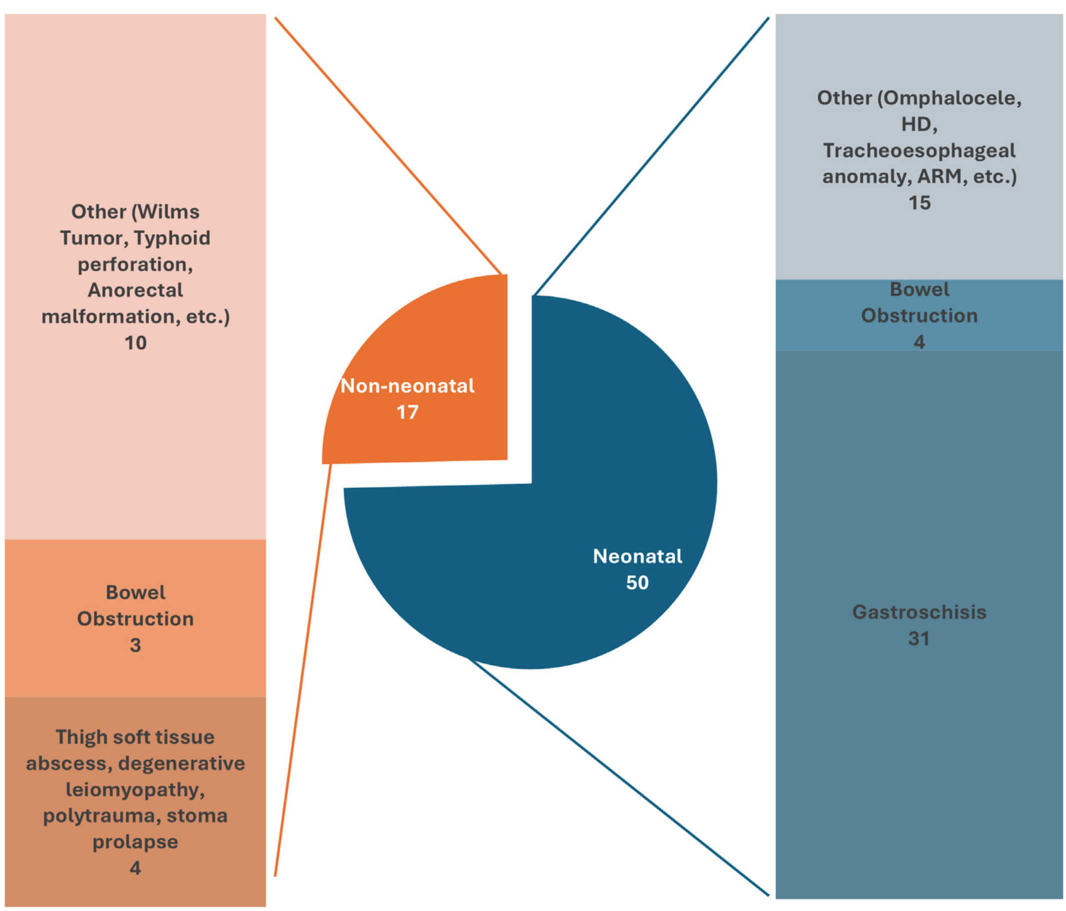

Fig. 2. Distribution of mortality by diagnosis. Frequency of mortality by pediatric sub-population and associated diagnoses.

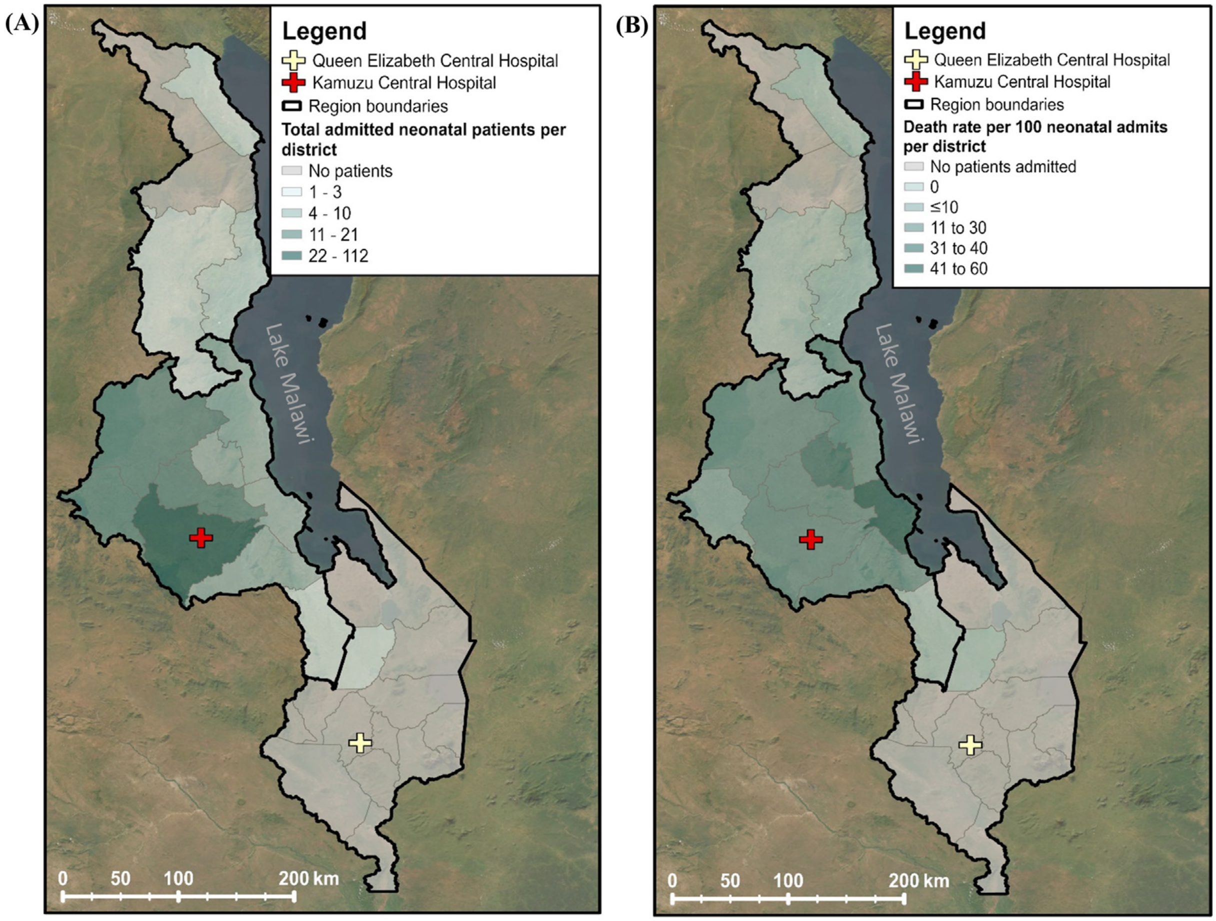

Fig. 3. Neonatal surgical disease. Choropleths showing (**A**) total neonatal admissions by district and (**B**) in-hospital deaths per 100 neonatal admissions.

within different patient subgroups. These effects are not paralleled for non-neonatal admissions. This finding may be explained by the time required for appropriate care, the necessity of specialized training, and the fact that equipment is more pertinent for neonatal surgical admissions than non-neonatal surgical admissions.

Patients presenting to KCH for a neonatal surgical disease from greater distances will likely be stable enough to survive prolonged transport at the beginning of their clinical course. They ultimately have better reported in-hospital outcomes than patients presenting from shorter distances to KCH. Our findings on the prevalence of minibus use and ambulance use for district hospitals to send patients to KCH corroborates published studies showing the public minibus system to be one of the most commonly used transport methods in Malawi [14]. There is no government-provided emergency transport system for citizens requiring care; existing ambulance services are commonly used for inter-facility transport. Neonatal admissions that are not stable enough to transport long distances may be prematurely palliated either at home, in primary, or secondary-level health facilities, thereby leading to a gap in true prevalence, referral patterns, and mortality of neonatal surgical disease in Malawi. Per the most recent Demographic and Health Survey completed in 2016, 92.8 % of births in Malawi take place at a healthcare facility [15]. Approximately 51 % of pregnant women receive 4 or more prenatal care visits from skilled providers (i.e. doctors, medical officers, clinical officers, midwives, nurses and medical assistants). There are limited data on population-wide prevalence of prenatal ultrasound imaging and subsequent identification of neonatal anomalies; however, site-specific programs emphasizing ultrasound training to determine accurate gestational ages have recently been gaining traction [15–17].

Task shifting has been used in many resource-limited settings to address shortages in health care providers and improve access to care [18,19]. In northern Malawi, a tertiary government health facility with no formal pediatric surgical workforce or infrastructure can provide medical and operative management for many non-neonatal patients. However, the relatively limited volume of neonatal disease and its management complexity make task-shifting to non-specialty workforces at other health facilities in Malawi more challenging.

Our findings are consistent with prior reports of all-cause mortality trends in Malawi. In 2014, a 7 % in-hospital mortality rate for 1170 pediatric surgical admissions to KCH was reported, with in-hospital deaths for patients less than 30 days old comprising 62.5 % of the observed mortality rate [6]. A systematic review of pediatric surgical mortality from 2007 to 2012 estimated a 12 % all-cause mortality varying from 0 to 90 % across studies in low-middle income countries in Africa [20]. In another prospective, international multicenter study, the all-cause mortality from gastrointestinal congenital anomalies was estimated to be 6–7 times higher in low-income countries than in high-income countries [21]. Country income status conferred the highest effect on mortality, even when accounting for other significant factors such as prematurity, access to parenteral nutrition, and antenatal diagnosis. It is well established that mortality for neonatal surgical admissions far exceeds that for non-neonatal surgical admissions, and this is exacerbated by the majority of congenital anomalies presenting in low-resource

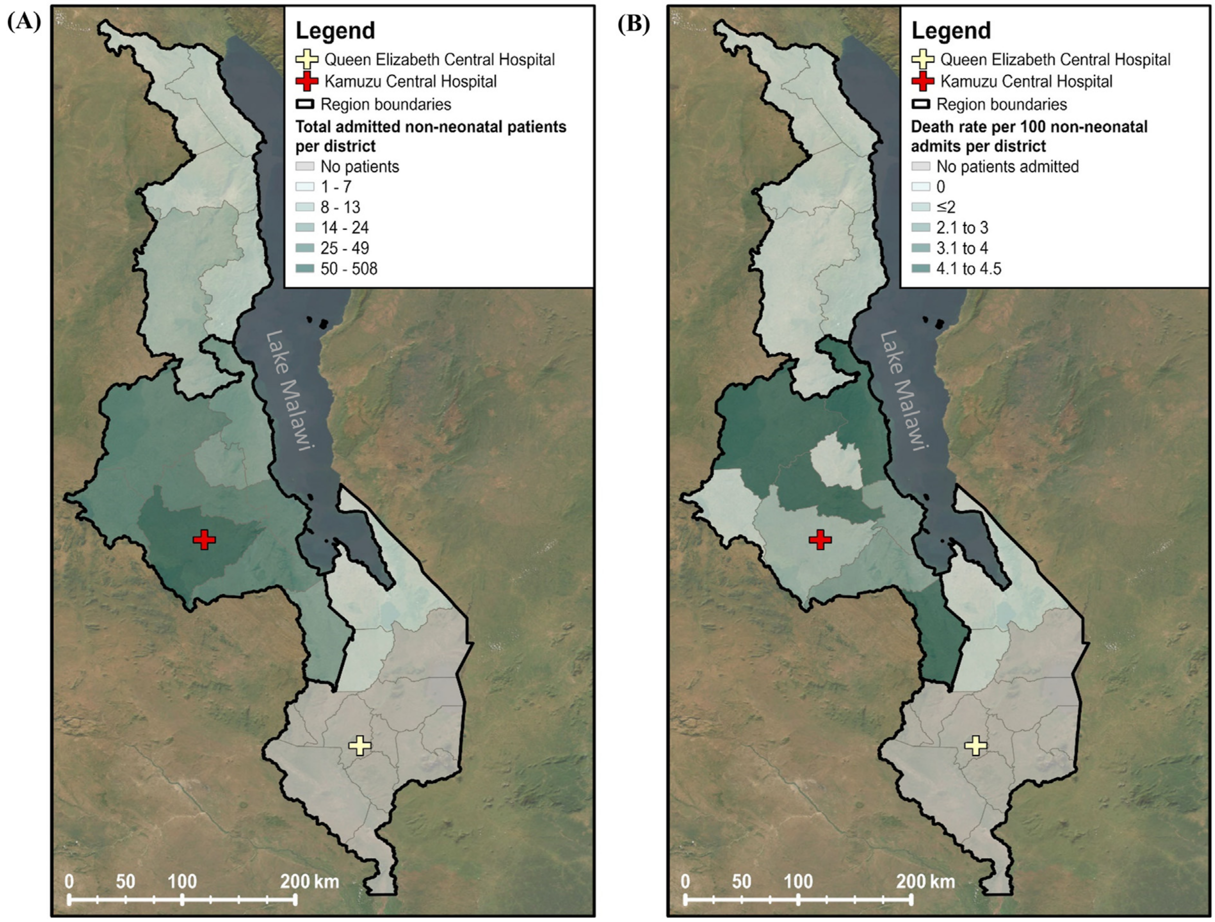

Fig. 4. Non-neonatal surgical disease. Choropleths showing (**A**) total non-neonatal admissions by district and (**B**) in-hospital deaths per 100 non-neonatal admissions.

settings [22–24]. Despite proven parallels of predictive patient factors on mortality of surgical disease, predictive factors in the peri-operative setting in and out of the hospital have yet to be as thoroughly studied as they may be more difficult to standardize and define.

In Somaliland and Uganda, service network analyses based on available road maps have characterized geographic and timely access to pediatric surgical services [25,26]. Similarly, geospatial mapping of exact facility services available to patients in Congo highlights vulnerable populations at the periphery of centers equipped with specialists and critical care equipment [27]. However, there is limited data correlating geographic and time-related access to pediatric surgical care with in-hospital mortality in Africa. A retrospective national study in Brazil observed correlations between constrained access to care and under-5 mortality for commonly seen pediatric surgical disease that was not mirrored in the 5 to 14-year-old population, but this was made possible in the context of accessible, national-level data on health facilities services, the incidence of disease, and age-specific mortality rates [28]. Limitations in digital infrastructure and workforce capacity hinder the development of a granular burden of disease metrics, facility services, and post-operative mortality metrics on a national scale in Malawi.

This study has several limitations in addition to those inherent to the retrospective methodology. A challenge associated with retrospective research in Malawi is the paper-based documentation of patient clinical course. This results an additional step of information processing whereby clinician-written records used for daily patient care are transliterated to research databases. As such, research data is made vulnerable to errors recording and interpretation. Furthermore, due to the limited ability to obtain prompt diagnostic imaging and laboratory studies, documented diagnoses for surgical patients on admission vary from post-operative pathologic diagnoses. The analysis presented is also limited to geographic location of the patient home residences. This method allows estimation of a catchment area and overlay of mortality trends, but does not account for the entirety of a patient's care seeking journey from symptom onset to being assessed at a nearby facility to escalation of care to KCH. This study's retrospective analysis does, however, provide novel insight into the geographic prevalence of pediatric surgical disease as serviced by KCH.

5. Conclusion

Neonatal surgical admissions are at significantly increased risk of in-hospital mortality compared to older patients. Distance plays a vital role in accessing pediatric surgical care for neonatal admissions. There is a continued gap in information on access to surgical care for neonatal disease in the northern region of Malawi, which lacks a pediatric surgical referral center. Focused efforts on standardized documentation and accessible outcomes data are needed to accurately quantify the unmet surgical needs of the pediatric population in the country. Assessing national incidence and morbidity of pediatric surgical disease at all health care facilities would inform more efficient surgical capacity building. Future analyses would guide the strategic placement of surgical infrastructure and workforce within the country, and establish outcome metrics for departments to improve the quality of care provided. With the continued increase in workforce and pediatric surgery trainees nearing the end of their training, strategic placement of new consultants has potential to build neonatal surgical care capacity at other tertiary government care facilities; doing so, specifically in Northern Malawi, may improve access disparities associated with poor outcomes for neonatal transfers to KCH. In addition to building capacity in rural areas of Malawi, quality improvement initiatives within KCH, especially for neonatal care, targeted at adherence to pre-referral resuscitation guidelines, improving nurse to patient ratios, and timely escalation of care via standardized communication processes to the on-service physician team could significantly improve mortality. KCH-centered initiatives should be undertaken in tandem with fostering growth in community care to continue to decrease pediatric surgical mortality in Malawi.

Previous communication

Invited manuscript submission for oral presentation at AAP 2024 Annual meeting.

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Appendix A. Supplementary data

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