Research Square

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Surgical Outcomes in a Neonatal Intensive Care Unit: A Retrospective Cohort Study at a Tertiary Care Hospital in Rawalpindi, Pakistan

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Abstract

Background

Despite carrying a substantial portion of the global surgical burden, neonatal surgical care in lower-middle- income countries (LMICs) remains understudied and often neglected in public health initiatives. This retrospective cohort study aimed to assess the burden of neonatal surgical conditions and identify factors affecting their outcomes in a tertiary care hospital in Rawalpindi, Pakistan.

Methods

The study included 419 children admitted to the NICU between July 27, 2022, and June 4, 2024. Data was collected from existing records of patient admissions. All surgical conditions were included in the study, but admissions with missing information were excluded. Outcomes were stratified into survival and expiry. Data was analyzed using logistic regression.

Results

Of the 419 patients included in this study, 56.8% (n = 238) were male and 43.2% (n = 181) were female. The majority of cases (94%) were congenital diseases. Gastrointestinal conditions had the highest mortality rate (31.3%; n = 47), followed by cardiovascular conditions (24%; n = 36) and neurological conditions (15.3%; n = 23). Mortality was highest in extremely preterm infants (75%; n = 3). Multivariable logistic regression showed that preterm neonates had significantly lower odds of survival compared to term neonates (AOR: 0.52, 95% CI: 0.33–0.85, p = 0.008). System of disease was also significantly associated with outcome, with gastrointestinal and respiratory conditions demonstrating the lowest odds of survival

Conclusion

This study analyzes the factors affecting outcomes of surgical diseases among children in the NICU in Pakistan, an understudied population. Our findings contribute to the limited body of evidence on neonatal surgical outcomes in LMICs and provide a foundation for future research that may help improve clinical practices and health policy development.

Background

Surgical diseases comprise almost one third of the global burden of illness [1]. Low- and middle-income countries (LMICs) carry a disproportionate share of this burden [2]. In most LMICs, children make up over half the population. Estimates from data collected in sub-Saharan Africa show that 85% of children in LMICs have a surgically treatable condition by the age of 15 [3].

Despite advancements in public healthcare and medical technology, access to surgical care remains limited in LMICs. More than 95% of the population in South Asia and sub-Saharan Africa do not have access to adequate surgical care, whereas less than 5% of the population in Australia, high-income North America, and Western Europe lack such access [4]. Patients in LMICs who do have access to surgical care suffer from disproportionately higher mortality rates: 96% of all perioperative deaths worldwide occur in LMICs [5].

Children, especially those in the NICU, are at a critical stage in their development. Child health and survival have always been cornerstones of public health efforts and are integral to the WHO's Sustainable Development Goals (Target 3.2: end preventable deaths of newborns and children under 5 years of age) [6]. In 2022, Pakistan's neonatal mortality rate was 38.8 per 1000 live births [7]. The WHO target for 2030 is to

have all countries reduce their neonatal mortality rate to 12 per 1000 live births.

Neonatal surgical conditions contribute substantially to preventable neonatal deaths in LMICs. Improving outcomes for this population is essential in lowering Pakistan's neonatal mortality rate. Progress in this area remains hindered due to the lack of analytical studies providing data about factors contributing to the mortality rate. Although small-scale studies on pediatric surgical cases have been conducted in Pakistan, there is a notable absence of large-scale, population-representative studies that systematically assess the burden of neonatal surgical diseases [8].

This study aims to define the burden of disease and the factors affecting outcomes of neonatal surgical conditions in a tertiary care hospital in Rawalpindi, Pakistan. These findings will improve neonatal surgical research and identify areas where targeted interventions can reduce morbidity and mortality.

Materials And Methods

Setting

According to the World Bank, Pakistan is one of the fifty-one lower-middle-income countries in the world [9]. Rawalpindi is the fourth largest city in Pakistan by population [10]. Pak Emirates Military Hospital (PEMH) is one of the largest tertiary care hospitals in the city, serving as a major referral center for patients from smaller cities and rural areas in the provinces of Punjab and Khyber Pakhtunkhwa (KPK). Healthcare at PEMH operates under an entitlement-based system: children of serving or retired military personnel receive care free of cost covered by the military, while civilian patients are admitted as private cases and are completely self-financed.

The NICU at PEMH has a capacity of 90 beds and 20 ventilators, with dedicated pediatric specialists including three consultant neonatologists, three pediatric surgeons, one pediatric anesthesiologist, and 18 pediatric-trained nurses. In addition to this specialized team, the unit is supported by pediatric residents, house officers, and general nursing staff.

The NICU admits both inborn and outborn cases. Inborn cases are those delivered within the hospital, while outborn cases are referred from nearby secondary-care facilities and private clinics that lack neonatal surgical and ventilatory capabilities. The patient population at this institution reflects the diverse demographics and health challenges within these areas.

Study Design

This is a hospital-based retrospective cohort study. The source population for this study was all patients admitted to the NICU between July 27th, 2022, and June 4th, 2024. The study population was children diagnosed with surgical conditions. All patient data was collected from existing records in the patient register in the NICU. All admissions with a documented diagnosis of a surgical condition in the patient data register were included in the study. Any admissions with missing information were excluded. Out of a total of 6,168 admissions into the NICU during the study period, 419 admissions met the inclusion criteria and were enrolled in the study. Data collected included gender, age at admission, duration of admission, gestational age (recorded in completed weeks), birth weight (measured in grams at birth), mode of delivery (vaginal or cesarean section), indoor/outdoor admission status, the diagnosis, and the outcome of the admission. Data was de-identified, entered into an Excel spreadsheet, and analyzed using PSPP v. 2.0.1. This study was evaluated and approved by the ethical review committee at Pak Emirates Military Hospital, Rawalpindi.

Data Analysis

Descriptive statistics were used to summarize the gender, age, gestational age, birth weight, mode of delivery, indoor/outdoor status, diagnosis, and duration of admission. Associations between variables were assessed using Chi-square tests or a one-way analysis of variance (ANOVA) as appropriate. Outcomes were recorded as survived or expired. To determine the significant predictors of outcomes, binary logistic regression was performed. This was followed by multivariable analysis to adjust for potential confounders such as gestational age, birth weight, mode of delivery, duration of admission, and indoor/outdoor status. Variables with low frequencies were combined into clinically meaningful groups to ensure model stability and avoid sparse-data bias. Adjusted odds ratios (AOR) with 95% confidence intervals (CI) were calculated to identify predictors of outcomes. A p-value of < 0.05 was considered statistically significant. Effect modification was not assessed in this study.

Patient and Public Involvement

Patients or the public were not involved in the design, conduct, reporting, or dissemination plans of this research. This study was based on a retrospective review of existing patient records. There was no direct interaction with patients or the public.

Results

During the study period (July 27th, 2022 - June 4, 2024), a total of 419 cases were enrolled. 238 (56.8%) of these cases were male and 181 (43.2%) were female. 332 (79.2%) patients were under the age of 7 days on admission. Sociodemographic characteristics are summarized in Table 1.

TABLE 1: Sociodemographic Characteristics

Variables	Category	Frequency (n)	Percent (%)
Gender	Male	238	56.8%
	Female	181	43.2%
Age	< 7 days	332	79.2%
	8-28 days	69	16.5%
	> 29 days	18	4.3%
Duration of Stay	< 7 days	283	67.5%
	8-14 days	73	17.4%
	15-21 days	35	8.4%
	22-28 days	17	4.1%
	> 28 days	11	2.6%

Data are presented as frequency (n) and percentage (%) of the total study population (n=419).

Diagnostic Distribution

Congenital anomalies accounted for 394 (94%) cases. The other 25 (6.0%) cases were acquired conditions. Gastrointestinal (GI) conditions were the most frequently seen, representing 100 (23.9%) of the total cases, followed by cardiovascular (n =96, 22.9%), and neurological (n=92, 22.0%) conditions (Figure 1).

Mortality rates varied significantly across different diagnoses. Though respiratory conditions presented less frequently in our study population, making up only 27 cases (6.4%), they carried the highest mortality rate (n =21, 77.8%). Mortality rates by system of disease are illustrated in Figure 2.

Table 2 summarizes the most frequent conditions seen in our population and their associated mortality rates. Tracheoesophageal fistula (20/24, 83.3%) and diaphragmatic hernia (13/16, 81.3%) carried the highest mortality rates.

TABLE 2: Frequency and Mortality of Common Surgical Diagnoses.

Condition	Frequency (n)	% of Total Conditions	Deaths (n)	% Mortality
Congenital Heart Disease	96	22.9%	36	37.5%
Meningomyelocele	58	13.8%	14	24.1%
Tracheoesophageal Fistula	24	5.7%	20	83.3%
Duodenal Atresia	22	5.3%	15	68.2%
Intestinal Obstruction	20	4.8%	3	15.0%
Diaphragmatic Hernia	16	3.8%	13	81.3%

All cardiac cases were recorded as “CHD” in the data source (mainly ASD and VSD). Further diagnostic stratification was not available. Data are presented as frequency (n), percentage of total conditions (%), deaths (n), and mortality as a percentage (%) per diagnosis.

Associations Between Clinical Variables and Outcomes

Associations between clinical variables were tested to characterize any significant relationships and their influence on patient mortality.

Gestational age was categorized according to The American College of Obstetricians and Gynecologists definitions into 6 groups: Extremely preterm (< 28 weeks), Very preterm (28-32 weeks), Moderate to late preterm (32 to 37 weeks), Early term (37-38 weeks), Full term (39-40 weeks), and Late-term (41 weeks) [11].

One-way ANOVA results revealed a significant effect of the gestational age group on the duration of hospital admission ($F(5, 413) = 5.80$, $p < 0.001$). The group with the longest mean duration of admission was the Very Preterm group (30 days). Extremely preterm infants had the shortest mean duration of stay (3 days). This reflects early mortality rather than discharge, as this group also had the highest mortality rate at 3 deaths out of the total 4 cases (75%). Chi-Square analysis showed a significant association ($\chi2(10) = 21.77$, $p = 0.016$) between gestational age and mortality, with mortality rates decreasing as gestational age increased, as depicted in Figure 3.

There was no statistically significant association between age group and outcome ($\chi2(4) = 3.71$, $p = 0.446$). Although the majority of patients in all age groups survived, the highest mortality was observed in neonates aged <7 days (123/332, 37%).

Neonates who survived and were discharged were seen to have a higher mean birth weight compared to those who expired (2.78kg vs. 2.59 kg). This difference was statistically significant ($t(257.24) = -3.26$, $p = 0.001$, 95% CI: −0.31 to −0.08), indicating that lower birth weight was associated with increased mortality.

Inborn/outborn status showed no significant association with outcome ($\chi2(2) = 0.03$, $p = 0.984$). Similar mortality rates were seen with both inborn (n=70, 35.9%) and outborn patients (n= 80, 35.7%).

Multivariable Analysis

Binary logistic regression showed gestational age (Wald $\chi2(1) = 6.96$, $p = 0.008$) and system of disease (Wald $\chi2(4) = 32.10$, $p < 0.001$) were significantly associated with the outcome. In contrast, no statistically significant association with the outcome was seen for gender (Wald $\chi2(1)=0.02$, $p=0.902$), age group (Wald $\chi2(2)=1.95$, $p=0.377$), mode of delivery (Wald $\chi2(1)=0.03$, $p=0.868$), inborn/outborn status (Wald $\chi2(1)=0.01$, $p=0.907$), duration of admission (Wald $\chi2(4)=2.53$, $p=0.639$), or birth weight (Wald $\chi2(1)=2.31$, $p=0.129$).

In multivariable logistic regression adjusting for gender, age at admission, gestational age, mode of delivery, birth weight, indoor/outdoor status, duration of admission, and system of disease, gestational age remained significantly associated with the outcome (Wald $\chi2(1) = 6.91$, $p = 0.009$). Preterm neonates had significantly lower odds of survival compared to term neonates (AOR: 0.52, 95% CI: 0.31-0.86, $p = 0.008$). The multivariate analysis can be seen in Table 3.

System of disease was also significantly associated with outcome (Wald $\chi2(4) = 32.10$, $p < 0.001$). Among the systems studied, Gastrointestinal conditions (n = 100, 23.9%; AOR: 0.26, $p < 0.001$) demonstrated the lowest odds of survival compared to other systems. Neurological conditions (n = 92, 22.0%; AOR: 0.67, $p = 0.259$) showed lower odds of survival, although it did not reach statistical significance.

Birth weight (AOR: 0.70, $p = 0.129$), age group, duration of admission, gender, mode of delivery, and inborn/outborn status were not significantly associated with outcome.

The logistic regression model demonstrated a modest fit to the data (−2 Log likelihood = 487.78; Nagelkerke R2 = 0.18) and correctly predicted the outcome in 70.9% of cases.

TABLE 3: Multivariable binary logistic regression analysis of factors associated with survival outcomes

Variable	Category	B	SE	Wald χ^2	p-value	AOR (Exp(B))	95% CI
Gender	Male vs Female	0.03	0.23	0.02	0.902	1.03	0.66-1.60
Mode of Delivery	SVD vs LSCS	0.04	0.23	0.03	0.868	1.04	0.66-1.64
Inborn/Outborn	Inborn vs Outborn	-0.03	0.26	0.01	0.907	0.97	0.58-1.62
Age Group	<7 days	Reference					
	8-28 days	-0.86	0.63	1.86	0.173	0.42	0.12-1.46
	>29 days	-0.90	0.67	1.79	0.180	0.41	0.11-1.51
Duration of Admission	<7 days	Reference					
	8-14 days	-0.44	0.71	0.38	0.535	0.64	0.16-2.59
	15-21 days	-0.20	0.75	0.07	0.788	0.82	0.19-3.53
	22-28 days	-0.23	0.80	0.08	0.771	0.79	0.16-3.81
	>28 days	0.48	0.96	0.25	0.620	1.61	0.25-10.52
System of Disease	Other	Reference					
	Gastrointestinal	-1.33	0.33	16.52	<0.001	0.26	0.14-0.50

The table shows adjusted odds ratios (AORs), standard errors (SE), Wald chi-square statistics, p-values, and 95% confidence intervals (CI) for demographic, perinatal, and clinical variables. A p-value <0.05 was considered statistically significant.

Discussion

Neonatal surgical care is an area that is often overlooked during global health initiatives in LMICs, where the focus tends to be on communicable diseases and maternal mortality. Analyzing the factors affecting neonatal surgical outcomes is a crucial first step in developing effective policies and healthcare guidelines aimed at improving neonatal surgical services in LMICs.

This retrospective study summarizes the epidemiological data and analyzes factors influencing the outcomes of surgical conditions treated in the NICU at Pak Emirates Military Hospital, Rawalpindi. Our data showed that increasing gestational age significantly increased the odds of survival, while being diagnosed with a gastrointestinal condition was associated with lower odds of survival.

In this study, there was a slight gender disparity between male admissions (56.8%) and female admissions (43.2%). A larger gap was reported in a study from Rehman Medical Institute, Peshawar, Pakistan, where 63.3% of patients were male and 36.71% were female [12]. An even greater difference was observed in Larkana, Pakistan, where 76.4% of patients were male compared to just 23.6% of females [13]. These numbers reflect the effects that cultural and societal factors have on healthcare-seeking behavior. Traditional gender biases, limited healthcare infrastructure, and financial constraints can cause delays in seeking or receiving care for female neonates.

Gastrointestinal conditions were the most commonly seen in our study, making up 23.6% of cases. This finding is consistent with a study conducted in the Dhiraj Hospital, Piparia, Vadodara, India where gastrointestinal conditions made up the highest number of admissions (40.9%) [14]. Our study revealed a notable difference in the prevalence of certain GI conditions, such as anorectal malformations, compared to similar studies done in other LMICs. At our institution, anorectal malformations made up 3.6% of total

cases, compared to 18.5% reported at Bapuji Child Health Institute & Research Centre in Karnataka, India [15]. A multicenter study conducted at 17 tertiary care centers in Nigeria also showed anorectal malformations (22.7%) being the most commonly diagnosed surgical condition in the NICU [16]. This regional variation may be due to the delayed presentation of anorectal malformation cases in Pakistan, an issue documented by Sohail et al [8]. This may lead to higher pre-admission mortality rates, reducing the number of cases reaching our tertiary care facility. Patterns of disease burden across different LMICs tend to align due to their shared challenges: limited neonatal surgical capacity, lack of specialized personnel, and barriers to timely care. These patterns shift in areas that do not share similar challenges.

There is a clear contrast between the trends of the most common surgical conditions between LMICs and higher-income countries. B. Nandi et al compared two linked surgical departments in Tanzania and the UK [17]. They found that the most common surgical condition in the NICU in Tanzania was anorectal malformations (9.5%). However, in the UK, necrotizing enterocolitis (10.2%) and gastroschisis (5.5%) were more commonly seen. A. Withers et al also reported necrotizing enterocolitis (34.34%) and gastroschisis (10.10%) as the most frequent admissions in South Africa [18]. This shift in the pattern of disease burden shows how improving infrastructure and access to care can alter which conditions present most frequently. Strengthening prenatal diagnostics and access to neonatal surgical facilities in Pakistan could similarly change our landscape of disease burden. Conditions that are most often fatal or under-diagnosed could become manageable surgical conditions.

The significance of gestational age as a predictor of neonatal surgical outcomes is highlighted across multiple studies, including this one. We observed that preterm neonates had significantly lower odds of

survival compared to term neonates (AOR: 0.52, 95% CI: 0.33–0.85, p = 0.008). This finding is consistent with results from Edan et al. in Mosul, Iraq, where preterm neonates had significantly higher mortality rates (RR: 3.560, CI: 2.235–5.670, p < 0.0001) [19]. Manchanda et al. in New Delhi, India also identified gestational age as a significant determinant, with preterm deliveries being associated with a threefold increased risk of adverse outcomes in neonates undergoing surgery [20]. Though birth weight was not a significant factor in this study's multivariate analysis, it still had a borderline association with the outcome. Our findings show that a 54% increase in the odds of survival for each unit increase in birth weight. Edan et al. also showed that neonates under 1.5 kg had the highest mortality risk [19]. These results confirm the vulnerability of pre-term and low-birth infants, where underdeveloped organ systems and immune function can increase susceptibility to adverse outcomes [20].

The majority of research focused on NICU patients in Pakistan is made up of cross-sectional studies that only provide epidemiological data, such as patient demographics, disease frequencies, and mortality rates [21,22]. The retrospective cohort design of our study allowed us add a new dimension and analyze the factors that influence these mortality rates, an important step toward gathering evidence that can inform clinical decisions and health policies. The inclusion of a wide range of variables, such as gender, age, gestational age, birth weight, and mode of delivery, ensures that our analysis is multifaceted. Our study accounts for any possible confounders and interactions between variables through the use of logistic regression, giving us a more comprehensive interpretation of the results.

Limitations & Future Research

This study has several limitations that warrant discussion. Firstly, as a single-center study, our findings may have limited generalizability to other regions or healthcare systems in Pakistan or other LMICs. However, it is important to note that Pak Emirates Military Hospital is a tertiary care center and is one of the main referral centers for smaller healthcare facilities in the region. As a result, our sample includes a substantial portion of the neonatal surgical burden within the area. Secondly, the handwritten patient register used as our primary source of data presented several limiting factors. Morbidity and operative data, such as how many patients underwent surgery, postoperative complications and non-fatal outcomes, were not documented in the register. As a result, our analysis may underestimate the true burden of disease caused by neonatal surgical conditions. Manual data entry into SPSS also created the possibility of transcription errors. To prevent this, we created digital copies of the original records. Both authors independently entered the data and cross-verified it to identify any discrepancies. Exclusion bias, however, cannot be completely ruled out due to the exclusion of incomplete data. Thirdly, the retrospective cohort design limits our ability to determine causal relationships between variables and the associated outcomes. That being said, this study design was appropriate for identifying associations and trends in surgical outcomes within a resource- constrained setting. These associations lay the groundwork for future studies aimed at determining causality. Prospective multi-center studies incorporating data about specific surgeries and associated morbidity are essential to developing targeted interventions.

While this study provides valuable insights into the factors affecting outcomes of neonatal surgery, it is only the first step in research focused on improving surgical mortality rates in Pakistan. The scope of this paper did not include key variables that would help contextualize the results. Socioeconomic factors, such as household income and education status, can affect access to and quality of care. Understanding how socioeconomic disparities can affect the outcomes of neonatal surgery can help identify vulnerable populations and create targeted strategies to reduce these disparities. Assessing the outcomes of different surgical techniques can inform future research into best practices in LMICs for high-risk conditions.

Including an analysis of postoperative complications and their contribution to mortality rates would provide a more comprehensive understanding of areas where care needs to be improved. Documenting the regions from which the most referrals originate will help identify high-burden areas and guide efforts to allocate resources and improve infrastructure, especially in resource-limited settings.

Conclusions

The findings of this study underline the vulnerability of preterm infants to poor surgical outcomes in the NICU. Clinicians should prioritize the early identification and management of preterm infants, as these patients are at higher risk for complications and poor outcomes. The gender disparity in admissions observed in our study and others conducted in Pakistan suggests that, despite progress in recent years, societal and cultural barriers continue to affect equitable access to neonatal healthcare. Continued efforts to address these disparities through public health interventions and education, particularly in rural areas, are important to improving equitable access to care for all children. Our study also highlights the high burden of congenital conditions in the NICU. Improvements in prenatal screening, antenatal care, and neonatal surgical services in resource-limited settings will be essential in mitigating these numbers.

As one of the few analytical studies examining neonatal surgical outcomes in Pakistan, our findings provide a foundation for future research exploring factors influencing neonatal surgical mortality and access to care in LMICs. Further multi-center and prospective studies building on these findings may help inform evidence- based clinical decision-making and healthcare policies aimed at reducing neonatal mortality in Pakistan and supporting progress toward achieving the WHO SDG Target 3.2 of reducing neonatal mortality to 12 deaths per 1,000 live births by 2030.

Declarations

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Ethical Review Committee, Pak Emirates Military Hospital issued approval A/28/EC/122/24. This study was approved by the Ethical Review Committee, Pak Emirates Military Hospital, Rawalpindi, Pakistan (Approval No: A/28/EC/122/24). **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In

compliance with the ICMJE uniform disclosure form, all authors declare the following: **Funding:** The authors received no financial support for the research, authorship, and/or publication of this article. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work. **Clinical Trial number:** Not applicable

Authorship Credits:

Acquisition, analysis, or interpretation of data: SA, HI, AK

Drafting of the manuscript: SA, HI

Critical review of the manuscript for important intellectual content: SA, HI, AK

Concept and design: AK

Supervision: AK

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Author Contribution

All authors have agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.Acquisition, analysis, or interpretation of data: SA, HI, AKDrafting of the manuscript: SA, HICritical review of the manuscript for important intellectual content: SA, HI, AKConcept and design: AKSupervision: AK

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Figures

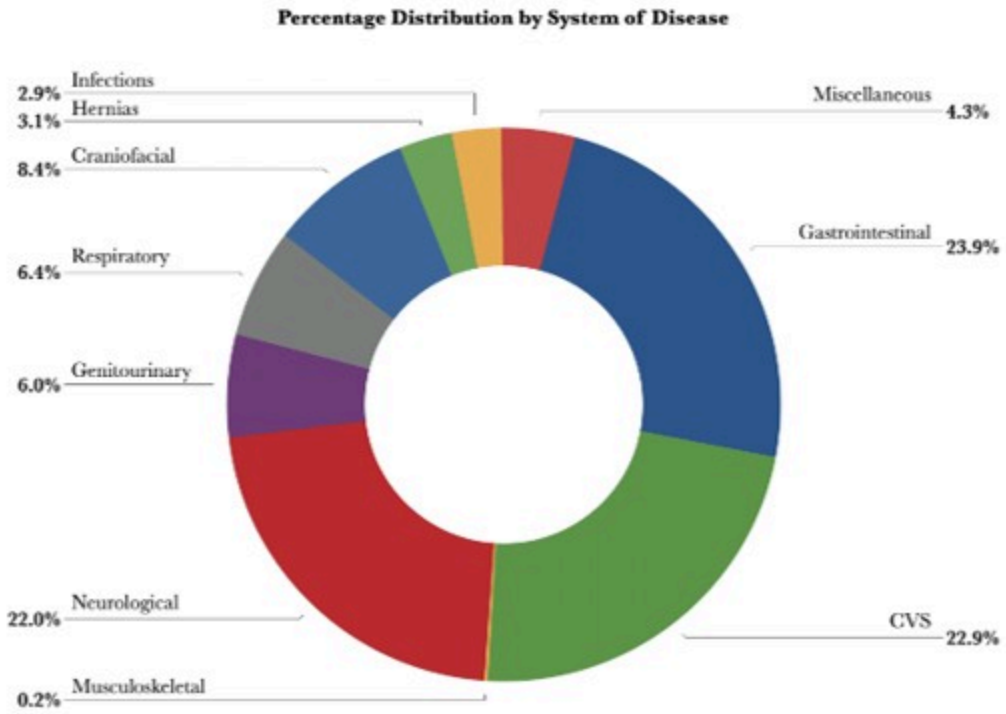


Figure 1

Distribution of diagnoses by organ system.

Data are presented as percentages (%) of total cases (n=419).

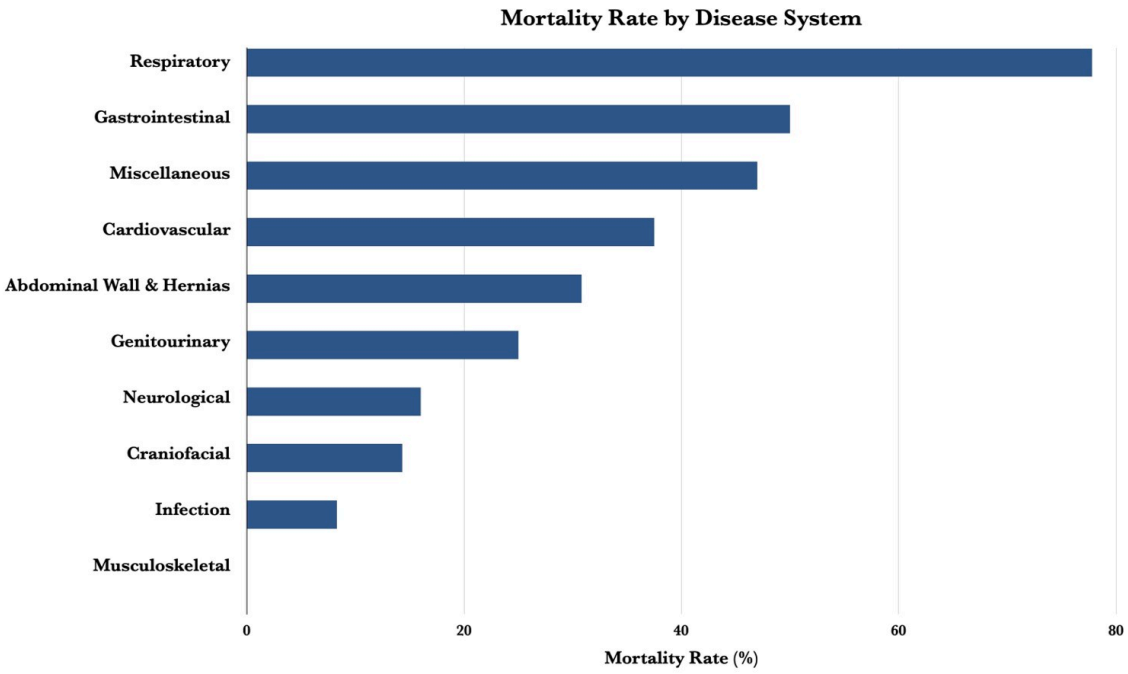


Figure 2

Mortality rates across different disease systems.

Data are presented as mortality (%), calculated as the proportion of deaths within each disease system.