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Clinical Characteristics and In-Hospital Mortality Outcomes of Admitted Neonates at the MSF-Supported Al-Salam MOH Hospital, Amran Governorate, Yemen

A Retrospective Descriptive Analysis

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Abstract

Background

Globally, about 2.3 million neonates die annually, most of them in low-resource and conflict-affected countries. In Yemen, ongoing humanitarian crises put children at continued risk, with neonates being the most vulnerable

group. This study aimed to assess the in-hospital neonatal mortality rate and to describe the demographic and clinical characteristics.

Methods

A retrospective cohort design reviewing all neonatal admissions to the Neonatal Inpatient Department (NIPD) at Al-Salam Hospital in Amran Governorate, January to December 2023. Data were extracted from hospital records entered REDCap and analyzed using R 4.3.1. Both descriptive and inferential statistics were applied: chi-square, t-tests for bivariate analysis, and logistic regression was used to identify predictors of neonatal mortality. Statistical significance at $p < 0.05$.

Results

A total of 882 neonates were included; 51% were inborn and 49% outborn. Median age was 1 day (IQR 0-6) and a median admission weight of 2,500 g (IQR 1,860-2,975), male neonates accounted for 57%. The commonest diagnoses were clinically suspected sepsis (72%), low birth weight (48%), prematurity (32%), perinatal asphyxia (20%), and meningitis (5%).

Among neonates receiving oxygen (72%), HHFNC use was more common among mortalities (15% vs. 8%), no significant difference was observed for nasal cannula use (95% vs. 94%). Antibiotics were administered to 96% of neonates; among deaths, cefotaxime was most frequently used and for a shorter duration (37% vs. 17%; 1 vs. 5 days).

Antibiotic regimen modification was more frequent among neonates with in-hospital mortalities (40% vs. 23%), particularly when escalating to vancomycin (27% vs. 7.2%) and meropenem (31% vs. 10%).

Maternal risk factors, including PROM in 35% (45% lasting ≥ 18 h), history of abortions, lower gestational age, and low hemoglobin, were associated with increased risk of in-hospital mortality. The overall mortality rate was 17.4%. In multivariable analysis, very low birth weight (VLBW; <1500 g), perinatal asphyxia, and meningitis were independent mortality predictors, whereas admission after 7 days of life and higher maternal hemoglobin were associated with improved survival.

Conclusions

Neonatal mortality at Al-Salam Hospital remained high, and was associated with VLBW, prematurity, and perinatal asphyxia, highlighting the need to strengthen maternal care, neonatal resuscitation, Kangaroo Mother Care, and antibiotic stewardship in fragile humanitarian settings.

Key words: Yemen; neonatal mortality; predictors; humanitarian setting; low birth weight; prematurity

Background

Neonatal death remains a major risk during the first month of life worldwide. It accounts for approximately 2.3 million deaths annually. Nearly 80% of these deaths occur in low and middle-income countries (LMICs), particularly in sub-Saharan Africa and South Asia[1]. Facility-based studies from LMIC neonatal units commonly report high in-hospital mortality rates (IMR)

ranging between 14% and 20%. Across these studies, prematurity, low birth weight, intrapartum complications (asphyxia), and neonatal infections dominate as primary causes of death [2-5].

In Yemen, more than a decade of conflict has severely affected the most vulnerable populations, especially women, children under five, and newborns. The health system has been extensively damaged, with fewer than 45% of health facilities partly functional [6]. As a result, timely access to maternal and newborn care is limited. The neonatal mortality rate in Yemen remains high at 21 deaths per 1,000 live births in 2023, exceeding both the global average of 17 and the Middle East and North Africa (MENA) regional rate of 11 deaths per 1,000 live births [7, 8]. Hospital-based studies reinforce this burden. In Hajja governorate, two hospital-based studies reported in-hospital neonatal mortality rates of 22% and 30%, respectively. Prematurity, low birth weight, asphyxia, neonatal suspected sepsis, male sex, admission within the first 24 hours of life, and delivery outside the hospital were identified as major predictors of death [9, 10].

Earlier studies, such as that at Al-Gumhuri Teaching Hospital in Sana'a city (2013) reported in-hospital mortality rate of 23.2%; independent risk factors included prematurity, LBW, outborn status, and vaginal delivery [11]. At Al Sabeen Hospital in Sana'a, a 12-year audit of 10,546 admissions revealed a mortality rate of 20.4%, while Al Wahdah Teaching Hospital in Thamar reported a rate of 22.1% among 290 admissions [12, 13]. Together, these studies reveal persistently high facility-based neonatal mortality in Yemen,

primarily associated with prematurity, birth asphyxia, and sepsis, with outborn neonates particularly at risk due to delays in accessing timely quality care.

Médecins Sans Frontières (MSF) has maintained a continuous presence in Yemen since 2007, with a strong operational focus on maternal and child healthcare. Since 2010, MSF has been supporting Al-Salam Maternity and Child Hospital, a Ministry of Health (MoH) facility, located in Amran governorate. The hospital provides obstetric, neonatal, and pediatric care to populations within its catchment area and beyond.

Despite the high burden of neonatal mortality reported elsewhere in Yemen, there is limited published evidence from Amran governorate. This study aims to address this gap by describing the characteristics, outcomes, and predictors of mortality among neonates admitted to the NIPD at Al-Salam Hospital.

Methods

Setting

Al-Salam Hospital a Ministry of Health (MOH) facility supported by Médecins Sans Frontières (MSF) since 2010, is in Khamir District, central Amran Governorate, northern Yemen. The hospital has a standard capacity of 115 beds (expandable to 206), including 24 beds in the Neonatal Inpatient Department (NIPD), with a nurse-to-neonate ratio of 1:4 and an average of 80 neonatal admissions per month. The department provides comprehensive

neonatal care, including resuscitation, preventive therapies, nutritional support, and microbiology tests.

Study Design

Retrospective cohort study including all admitted neonates to the MSF-supported Al-Salam MOH Hospital, Khamir, Amran, Yemen, between 1 January and 31 December 2023. This was a retrospective observational study; therefore, associations do not imply causation.

Sample size

A total of 882 admitted neonates were included based on the inclusion criteria.

Inclusion and Exclusion Criteria

- *Inclusion Criteria:* Inborn and Outborn neonates admitted to NIPD.
- *Exclusion Criteria:* Neonates observed in the ER or Maternity but not admitted to NIPD. Files with missing or incomplete data were excluded.

Data Collection and Tools

Four trained encoders extracted data from clinical records into REDCap over a 15-day period (25Aug to 12 sep,2024). Reviewed documents included the NIPD Medical Card, Transfer Sheet (inborn), Treatment Sheet, ER Notes, Mortality Reports, Maternity Hospitalization File (inborn), and C-Section.

Study Variables

The primary outcome was in-hospital neonatal mortality, defined as death before discharge among admitted neonates, with all deaths occurring within the first 28 days of life. Referred and left-against medical advice cases were excluded from the mortality denominator and reported separately. Key exposure variables in this study were grouped into; Baseline characteristics, including age at admission, weight, sex, geographic location, place of delivery, and mode of delivery and final diagnoses, such as sepsis, prematurity, perinatal asphyxia, and low birth weight; Maternal factors, including maternal age and history of abortion where gestational age at abortion was not recorded. Current gestational age, and hemoglobin levels; treatment-related variables, limited to oxygen therapy and antibiotic use.

Study Definitions

Prematurity: Defined as birth before 37 completed weeks of gestation, based on the best available estimate from last menstrual period, antenatal records, or clinical assessment.[14]

Low Birth Weight (LBW): Any neonate with a birth weight of less than 2,500 grams.[15]

Inborn: Admitted Neonate delivered at MSF-supported Al-Salam MOH Hospital regardless of whether they were admitted directly from the maternal ward or ER, a few days after discharge from Maternity. [16]

Outborn: Admitted Neonate born outside of the MSF facility, including home births, births in non-MSF health facilities, during transportation, or in other non-clinical settings.[16]

Clinically Suspected Sepsis: Defined as any case clinically diagnosed as sepsis by the attending physician, who may be a pediatrician or a non-pediatrician clinician. Laboratory confirmation was not required due to the unavailability of diagnostic testing for all cases diagnosed; testing was performed for cases not responding to the antibiotics.[17]

Perinatal Asphyxia: Failure to initiate or sustain breathing at birth, often assessed clinically using a low apgar score (e.g., <7 at 5 minutes) or need for resuscitation.[18]

Maternal Anemia: Defined as hemoglobin level <11.0 g/dL during pregnancy, according to World Health Organization (WHO) criteria.[19]

Statistical Analysis

Descriptive statistics were used to summarize patient demographics, clinical characteristics, and outcomes. Categorical variables were presented as frequencies and percentages, while continuous variables were summarized using means with standard deviations or medians with interquartile ranges, depending on the distribution. Risk factor analysis included neonates with a documented outcome, so referred and defaulted neonates were excluded. Consequently, the analysis is restricted to in-hospital outcomes. Therefore,

the total number of neonates included in risk factor analysis is 744. Chi-square tests or Fisher's exact tests were used to compare categorical variables. For continuous variables, independent t-tests were applied for normally distributed data, while the Mann-Whitney U test was used for non-normally distributed data. Logistic regression was performed to identify factors associated with in-hospital mortality. Variables for the multivariable model were selected based on clinical relevance, bivariable analysis ($p < 0.20$), and data availability. Statistical significance was set at $p < 0.05$.

Ethics Approval

The study received ethical approval from the National Committee for Health and Medical Research at the Ministry of Health. In addition, the Médecins Sans Frontières (MSF) Ethics Review Board granted an exemption, acknowledging that the study aligns with anonymized routine data from programmatic activities.

Results

Demographic and Baseline Characteristics (N = 882).

A total of 882 neonates were included, the proportion of inborn and outborn neonates were almost similar. (448;51% vs 434:49%). Figure 1

The median age at admission was 1 day (IQR: 0-6), 57% were males. Among outborn deliveries, 74% (n=289) occurred at home or in a vehicle. Caesarian section delivery was more frequent among inborn (18%) than outborn (6%)

neonates. The median weight at admission was 2,500 g (IQR: 1,860–2,975). The most common diagnoses were suspected sepsis (72%), low birth weight (48%), prematurity (32%), and perinatal asphyxia (20%).

Inborn neonates were diagnosed more often with prematurity (39%, $p < 0.001$), perinatal asphyxia (28%, $p < 0.001$), and meconium aspiration syndrome (7.4%, $p < 0.001$). In contrast, outborn neonates were more likely to be diagnosed with suspected sepsis (83%), meningitis (11%, $p < 0.001$), and lower respiratory tract infections (10%, $p < 0.001$). Nearly half of cases had low birth weight (48%), with similar distribution between inborn and outborn neonates (49% vs 46%; $p = 0.3$). Table 1

Figure 1. Flowchart of the study sample of neonates admitted to Al Salam Hospital, Khamir, Yemen, 2023.

Figure 1: [Insert Figure 1 here]

Table 1 .Baseline and clinical characteristics of admitted neonates,

Al-Salam Hospital, Khamir, Yemen, 2023, (N = 882)

Table 1: [Insert Table 1 here]

Survival outcomes by baseline characteristics (N = 744)

Of the 744 neonates with documented in-hospital outcomes, 129 died (17.4%; 95% CI: 14.7%–20.1%). Median age at admission was significantly lower among neonates who died (0 days [IQR 0–2]) compared to discharged (1 day [IQR 0–8], $p < 0.001$). In-hospital mortality was higher among preterm (52% vs 32% $p < 0.001$) and lower admission weight (median 1890g vs 2505g, $p < 0.001$). The risk of in-hospital mortality was higher among those diagnosed

with low birth weight (64% vs 46%, $p < 0.001$), suspected Sepsis, prematurity (50% vs 31%, $p < 0.001$) and perinatal asphyxia (31% vs 16%, $p < 0.01$). In-hospital Mortality was lower but significantly associated with meningitis (13% vs 5.2%, $p < 0.001$) and congenital anomalies (7.0% vs 1.3%, $p < 0.001$).

In contrast, sepsis was less frequent among neonates who died compared to those discharged (60% vs 75%, $p < 0.001$). Table 2

Among inborn neonates with available maternal data, higher in-hospital mortality was associated with maternal history of ≥ 3 abortions as documented in medical records ($p = 0.014$), prolonged rupture of membranes (≥ 18 hours; $p = 0.041$), lower hemoglobin levels ($p = 0.026$), and early labor (1-3 cm cervical dilation) ($p = 0.030$). Table S1: Additional file 1

Table 2. Bivariate Analysis of in-Hospital Neonatal Mortality by Baseline Characteristics, AL-Salam Hospital, Khamir, Yemen (N = 744).

[Insert Table 2 here]

Survival outcomes by oxygen support and antibiotic treatment

Among neonates receiving oxygen therapy (N = 541), HHFNC use was more common among neonates that died than those discharged (15% vs. 8%, $p = 0.017$), while no significant difference was observed with the use of nasal cannula. (94% vs. 95%, $p = 0.7$). Table 3

Table 3. Association Between Oxygen Therapy and in-Hospital Neonatal Mortality, Al Salam Hospital, Khamir, Yemen, 2023 (N = 541)**Table 3: [Insert Table 3 here]**

Nearly all neonates (96%) received antibiotics. Ampicillin and Gentamicin were the most frequent initial antibiotics prescribed, with an almost equal distribution between neonates discharged and those that died. However, Cefotaxime was more frequently used among neonates that died (37% vs. 17%; $p < 0.001$) and for a shorter duration (1 vs. 7 days, $p < 0.001$). Modification of antibiotics was more common among neonates who died compared with those who were discharged (40% vs 23%; $p < 0.001$), particularly when therapy included vancomycin (27% vs. 7.2%; $p < 0.001$) or meropenem (31% vs. 10%; $p < 0.001$). Table 4

Table 4. Antibiotic Use by Neonatal Outcome, AL-Salam Hospital, Khamir, Yemen, 2023 (N = 744)**Table 4: [Insert Table 4 here]****Multivariate Analysis of In-Hospital Mortality**

Multivariable logistic regression model including all neonates (Table S2A, Additional file 1) found that birth weight < 1500 g was strongly associated with in-hospital mortality (aOR 6.44; 95% CI 2.64-16.0; $p < 0.001$). Neonates aged > 7 days at admission had lower odds of in-hospital mortality compared to those < 24 hours (aOR 0.28; 95% CI 0.09-0.82; $p = 0.025$). Oxygen therapy was more frequently administered among neonates with in-hospital mortality than among those discharged (aOR 0.06; 95% CI 0.01-0.21; $p < 0.001$).A

higher frequency of antibiotic therapy modification was also observed among neonates with in-hospital mortality compared with discharged (aOR 1.62; 95% CI 0.99-2.63; $p = 0.053$). Higher odds of in-hospital mortality were observed among neonates with perinatal asphyxia (aOR 1.89; 95% CI 1.02-3.51; $p = 0.042$) and meningitis (aOR 2.27; 95% CI 1.04-4.87; $p = 0.036$). Other factors, including preterm birth, suspected sepsis, sex, and birth location, were not statistically significant in the adjusted model. Figure 2

In a subgroup analysis limited to inborn neonates with available maternal data, higher maternal hemoglobin (>11 g/dL) was associated with reduced neonatal in-hospital mortality (aOR 0.31; 95% CI 0.10-1.01; $p = 0.043$), whereas other maternal factors were not significantly associated with in-hospital mortality. Table S2B (Additional file 1)

Figure 2. Forest Plot of Adjusted-OR for in-Hospital Neonatal Mortality , AL-Salam Hospital, Khamir, Yemen, 2023 (N=744)

[Insert Figure 2 here]

Discussion

In this study, the in-hospital neonatal mortality rate was 17.4%, which is lower than the rate of the pre-conflict study at Al-Gumhouri Teaching Hospital, Sana'a (2013), also below the 21-30% range documented in more recent Yemeni studies from 2018-2022 [9-12]. likely due to differences in-hospital capacity and medical policies. However, our rate is higher than in other conflict-affected settings such as Libya, Iraq, and Ethiopia (ranging

between 7% and 16%) [2, 3, 5, 20]. This gap likely reflects the compounded challenges of the Yemeni context: Late presentation of outborn neonates, limited intensive care capacity beyond level II, shortages of specialized staff, and a fragile referral system. These factors highlight how prolonged conflict amplifies preventable mortality, even where humanitarian support is sustained.

In our cohort, the most frequent morbidities were suspected sepsis (72%), low birth weight (48%), prematurity (32%), and perinatal asphyxia (20%). This distribution is consistent with prior studies from Yemen [9-12] and with hospital-based data from other low- and middle-income countries (LMICs) [2, 3, 21]. The multiplicity of these conditions reflects both the perinatal risk environment, including high rates of maternal anemia, infections, and inadequate antenatal care, as well as the limitations of available diagnostics, particularly for neonatal suspected sepsis where microbiological confirmation was rarely feasible.

The finding that suspected sepsis was frequently diagnosed, yet not independently associated with mortality, highlights an important methodological and programmatic issue. In this context, “suspected sepsis” often serves as a syndromic label applied to a wide range of critically ill neonates, many of whom also present with prematurity or asphyxia. This diagnostic overlap may explain the lack of association with mortality in

adjusted analyses and suggests the need to strengthen case definitions, diagnostic capacity, and clinician training.

The burden of perinatal asphyxia highlights the importance of timely obstetric care and reliable newborn resuscitation capacity in the delivery ward, with strong linkages to the neonatal unit. This is consistent with evidence from Yemen and other low- and middle-income countries, where it remains a leading cause of neonatal mortality due to delays in intrapartum care, low skilled birth attendance, and limited resuscitation capacity. Similar findings have been reported across several regions in Yemen, including Sana'a, Hajjah, and Tamar, where perinatal conditions consistently contribute to neonatal morbidity and mortality.[9, 11-13, 15, 16]

The observed association between non-administration of oxygen therapy and reduced odds of in-hospital mortality likely reflects confounding by indication not a causal relationship whereby more severely ill neonates were more likely to receive oxygen therapy. Nearly all admitted neonates received antibiotics on admission. The most common initial regimen was the first-line combination of ampicillin and gentamicin, aligned with WHO and MSF recommendations for suspected neonatal sepsis[22, 23]. A smaller but significant proportion received meropenem and/or vancomycin (second-line agents) that were either given at initial therapy or after modification of antibiotics to the second regimen. The association between modification of antibiotic and higher in-hospital mortality likely reflects underlying illness severity and possible antimicrobial resistance, rather than a causal

relationship[24]. These findings highlight two interlinked challenges: the syndromic over-diagnosis of sepsis in the absence of reliable diagnostics, and the growing threat of antimicrobial resistance in fragile health systems. Cultures were rarely performed and usually only when first-line therapy failed, limiting the ability to detect resistance early or to guide antibiotic selection. This selective testing method limits the ability to characterize local pathogen patterns and antimicrobial resistance supporting reliance on broad-spectrum antibiotics.

In our study, maternal risk factors including history of multiple abortions, anaemia (lower hemoglobin levels), early labor, and prolonged rupture of membranes were associated with increased inborn in-hospital mortality. These factors are commonly reported and widely recognized in Yemen and other LMIC countries as major contributors to neonatal infection and death, underscoring the need for timely prevention and improved obstetric care.

Eighteen percent of deliveries among inborn were by caesarean section, with no impact on neonatal in-hospital mortality. This contrasts with some Yemen studies, where caesarean section was protective, and other LMIC studies, where it was associated with a higher risk, reflecting differences in-hospital practices and healthcare capacity [9, 25]. These findings underline the continuum of maternal-neonatal health and emphasize the importance of accessing safe obstetric care in enhancing neonatal survival in fragile contexts.

In multivariable analysis, in-hospital mortality was highest among neonates with very low birth weight, prematurity, and perinatal asphyxia, while deaths associated with meningitis/encephalitis, congenital anomalies, and lower respiratory tract infections were less frequent but still significant predictors. These patterns are consistent with previous hospital-based studies from Yemen and other low- and middle-income countries, where prematurity, low birth weight, and intrapartum complications remain the leading drivers of neonatal death [3, 9, 11]. Our findings highlight the urgent need for strategies that prevent prematurity, manage perinatal asphyxia, and address severe neonatal infections, while strengthening care for low-birth-weight neonates through evidence-based interventions such as Kangaroo Mother Care, nutritional support, and timely resuscitation [26, 27]. Among inborn neonates with maternal data, higher maternal hemoglobin (>11 g/dL) was independently protective against mortality, in line with evidence linking maternal anemia to adverse neonatal outcomes in Yemen and other LMIC. In Yemen, high rates of maternal anemia are largely driven by food insecurity, disrupted health and nutrition services in the context of prolonged conflict.[3, 9, 28]

A major strength of this study is the inclusion of a large cohort of neonatal admissions, providing rare data from a conflict-affected setting where evidence is scarce. The use of routine program data increases operational relevance. We recognized several limitations. Documentation was incomplete for some variables, particularly in emergency admissions. In addition,

diagnoses were primarily based on clinical assessment, which may have introduced misclassification bias. Residual confounding is also possible due to the absence of key severity indicators in the dataset. Defaulting and referred neonates were excluded from the survival analysis, which may have underestimated in-hospital mortality in this humanitarian setting. Antenatal care information lacked detail on adequacy or quality, and Kangaroo Mother Care, though practiced, was not consistently recorded. Finally, microbiological cultures were only obtained in selected cases, limiting the ability to assess pathogens and antimicrobial resistance. Overall, these factors may limit the generalizability of the findings beyond similar MSF-supported level II neonatal units in comparable humanitarian settings.

Conclusion

In-hospital neonatal mortality at Al-Salam Hospital remained high at 17.4%, driven primarily by very low birth weight, prematurity, perinatal asphyxia, and severe infections, while maternal anemia further intensified risk.

Oxygen therapy and antibiotic modification were more commonly observed among neonates who died, likely reflecting differences in underlying clinical severity. These findings are based on a retrospective observational study and should not be interpreted as evidence of treatment effects or causality.

These findings underline the urgent need to strengthen maternal health services, ensure readiness for neonatal resuscitation, expand Kangaroo Mother Care (KMC) with emphasis on zero separation and adequate spacing

to maximize its benefits, and promote rational antibiotic use in fragile contexts. Sustained investment in antenatal, intrapartum, and early neonatal care, alongside pragmatic quality-improvement measures, is essential to reduce preventable neonatal deaths in Yemen and comparable humanitarian settings.

Declarations

Abbreviations

AKI: Acute Kidney Injury.

CI: Confidence Interval.

C-Section: Caesarean Section.

ER: Emergency Room.

ERB: Ethical Review Board.

HHFNC: Humidified High-Flow Nasal Cannula.

IMR: In-Hospital Mortality Rate.

IQR: Interquartile Range.

KMC: Kangaroo Mother Care.

LBW: Low Birth Weight.

LRTI: Lower Respiratory Tract Infection.

LMIC: Low- and Middle-Income Countries.

MoH: Ministry of Health.

MSF: Médecins Sans Frontières.

NIPD: Neonatal Inpatient Department.

OR: Odds Ratio.

PROM: Prolonged Rupture of Membranes.

RDS: Respiratory Distress Syndrome.

REDCap: Research Electronic Data Capture.

WHO: World Health Organization.

Ethics approval and consent to participate

This study was approved by the Ministry of Health Ethics Committee, Yemen (Reference: 84, S.M) and received an exemption from the Médecins Sans Frontières Ethical Review Board (MSF-ERB). As this was a retrospective study using routinely collected, anonymized hospital data, the requirement for informed consent from parents or legal guardians of neonates was waived by both ethics committees, in accordance with national regulations and institutional guideline.

Clinical trial number

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

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

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions (CRediT format)

Rihana Abdulmoghni: Conceptualization; Methodology; Project administration; Data curation; Formal analysis; Investigation; Writing - Original Draft.

Rami Malaeb: Supervision; Methodology; Validation; Formal analysis; Writing - Review & Editing.

Evgenia Zelikova: Conceptualization; Resources; Ethics approval support.

Elisabeth Poulet: Methodology; Resources; Review of data collection instruments; Writing - Review & Editing.

Alain Ngamba: Project administration; Operational support; Resources.

Yousef Sultan: Resources; Data provision; Coordination with Ministry of Health; Validation.

Zakaria Al-Emad: Writing - Review & Editing (pediatric medical expertise); Support with Ministry of Health approvals.

Melissa Hozjan: Writing - Review & Editing (pediatric medical expertise).

Elizabeth Ledger: Writing - Review & Editing (pediatric medical expertise).

Uffaira Hafeez: Data curation; Formal analysis.

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Figures legend

Figure 1. Flowchart of neonate admissions and final study sample (n = 882), showing inborn (n = 448), outborn (n = 434), and outcomes including discharged, died, referred, and defaulted.

Figure 2. Forest plot of adjusted odds ratios (ORs) with 95% CIs for mortality among 744 admitted neonates. Squares = ORs; lines = 95% CIs; factors crossing 1 are not significant.

Table 1 .Baseline and clinical characteristics of admitted neonates, AL Salam Hospital, Khamir, Yemen, 2023, (N = 882).

Characteristic	Overall N = 882 N(%)	Inborn n = 448 n(%)	Outborn n = 434 n(%)	P- value ²
Age at Admission (days)¹	1 (0, 6)	0 (0, 0)	5 (1, 15)	<0.001
Sex				0.090
Female	383 (43)	207 (46)	176 (41)	
Male	499 (57)	241 (54)	258 (59)	
Weight at Admission (g)	2500 (1860, 2975)	2500 (1773, 2915)	2570 (1970, 3000)	0.008

Characteristic	Overall N = 882 N(%)	Inborn n = 448 n(%)	Outborn n = 434 n(%)	P- value²
Place of Delivery				<0.001
Home/car	289 (34)	-	289 (74)	
MSF facility	448 (53)	448 (100)	-	
Non-MSF Facility	102 (12)	-	102 (26)	
Missing	43	-	43	
Caesarean delivery	102 (12)	78 (18)	24 (6)	<0.001
Diagnosis at Discharge				
*				
Suspected Sepsis	632 (72)	273 (61)	359 (83)	<0.001
Low Birth Weight	419 (48)	221 (49)	198 (46)	0.3
Prematurity	286 (32)	174 (39)	112 (26)	<0.001
Perinatal Asphyxia	172 (20)	125 (28)	47 (11)	<0.001
Meningitis/Encephalitis	61 (6.9)	14 (3.1)	47 (11)	<0.001
Meconium Aspiration Syndrome	36 (4.1)	33 (7.4)	3 (0.7)	<0.001
Jaundice	33 (3.7)	12 (2.7)	21 (4.8)	0.091
Lower Respiratory Tract Infection (LRTI)	51 (5.8)	6 (1.3)	45 (10)	<0.001
Other diagnoses**	64 (7.3)	35 (7.8)	29 (6.7)	0.54

¹Values are presented as median (Q1, Q3)

²Pearson's Chi-squared test

*Multiple diagnoses for one neonate applied

**Other diagnoses include congenital anomaly, RDS, hypoglycemia, omphalitis, AKI, and tetanus

Table 2. Bivariate Analysis of Neonatal Mortality by Baseline Characteristics, AL-Salam Hospital, Khamir, Yemen (N = 744).

Characteristic	Discharge n = 615 n(%)	In-Hospital Mortality n= 129 n(%)	p- value²
Age at Admission (days)¹	1.0 (0.0, 8.0)	0.0 (0.0, 1.0)	<0.001
Sex			0.5
Female	260 (42)	59 (46)	
Male	355 (58)	70 (54)	
Birth location			0.042
inborn	297 (48)	75 (58)	
outborn	318 (52)	54 (42)	
Place of Delivery			0.3
MSF facility	297 (51)	75 (60)	
Non-MSF Facility	79 (14)	14 (11)	
Home	196 (34)	33 (27)	
car	8 (1.4)	2 (1.6)	
Missing	35	5	
Mode of Delivery			0.7
Caesarean section	72 (12)	13 (10)	
Vaginal - instrumental	29 (5.0)	5 (4.0)	
Vaginal - spontaneous	482 (83)	106 (85)	
Missing	32	5	
Weight at Admission (g)	2,505 (1,955, 3,000)	1,890 (1,295, 2,700)	<0.001
Term / Preterm	190 (32)	64 (52)	<0.001
Missing	17	6	
Pregnancy Type			0.4
Single	567 (92)	122 (95)	
Twins: Two fetuses.	36 (5.9)	6 (4.7)	

Characteristic	Discharge n = 615 n(%)	In-Hospital Mortality n= 129 n(%)	p- value²
Triplets: Three fetuses.	10 (1.6)	0 (0)	
Missing	2	1	
Diagnosis at Discharge			
Suspected sepsis	463 (75%)	77 (60%)	<0.001
Low Birth Weight	284 (46%)	82 (64%)	<0.001
Prematurity	190 (31%)	64 (50%)	<0.001
Perinatal Asphyxia	101 (16%)	40 (31%)	<0.001
Meningitis/Encephalitis	32 (5.2%)	17 (13%)	<0.001
Lower Respiratory Tract Infection (LRTI)	40 (6.5%)	3 (2.3%)	0.064
Jaundice	23 (3.7%)	6 (4.7%)	0.6
Meconium Aspiration Syndrome	24 (3.9%)	2 (1.6%)	0.3
Congenital Anomaly	8 (1.3%)	9 (7.0%)	<0.001
Other*	123 (20.0%)	18 (14.0%)	0.4

¹Values are presented as median (Q1, Q3)

²Pearson's Chi-squared test

*Other includes: LRTI, Jaundice, Meconium Aspiration, RDS, Hypoglycemia, Omphalitis, and AKI

Table 3. Association Between Oxygen Therapy and Neonatal Mortality, Al-Salam Hospital, Khamir, Yemen, 2023 (N = 541).

Characteristic	Discharge n = 415 n(%)	In-Hospital Mortality n = 126 n(%)	p-value¹
Nasal Cannula	396 (95%)	119 (94%)	0.7
HHFNC*	33 (8.0%)	19 (15%)	0.017

¹Pearson's Chi-squared test

*HHFNC: Humidified high flow nasal cannula

One neonate may receive more than one oxygen modality; pediatric face masks used were classified under nasal cannula

Table 4. Antibiotic Use by Neonatal Outcome, AL-Salam Hospital, Khamir, Yemen, 2023 (N = 744).

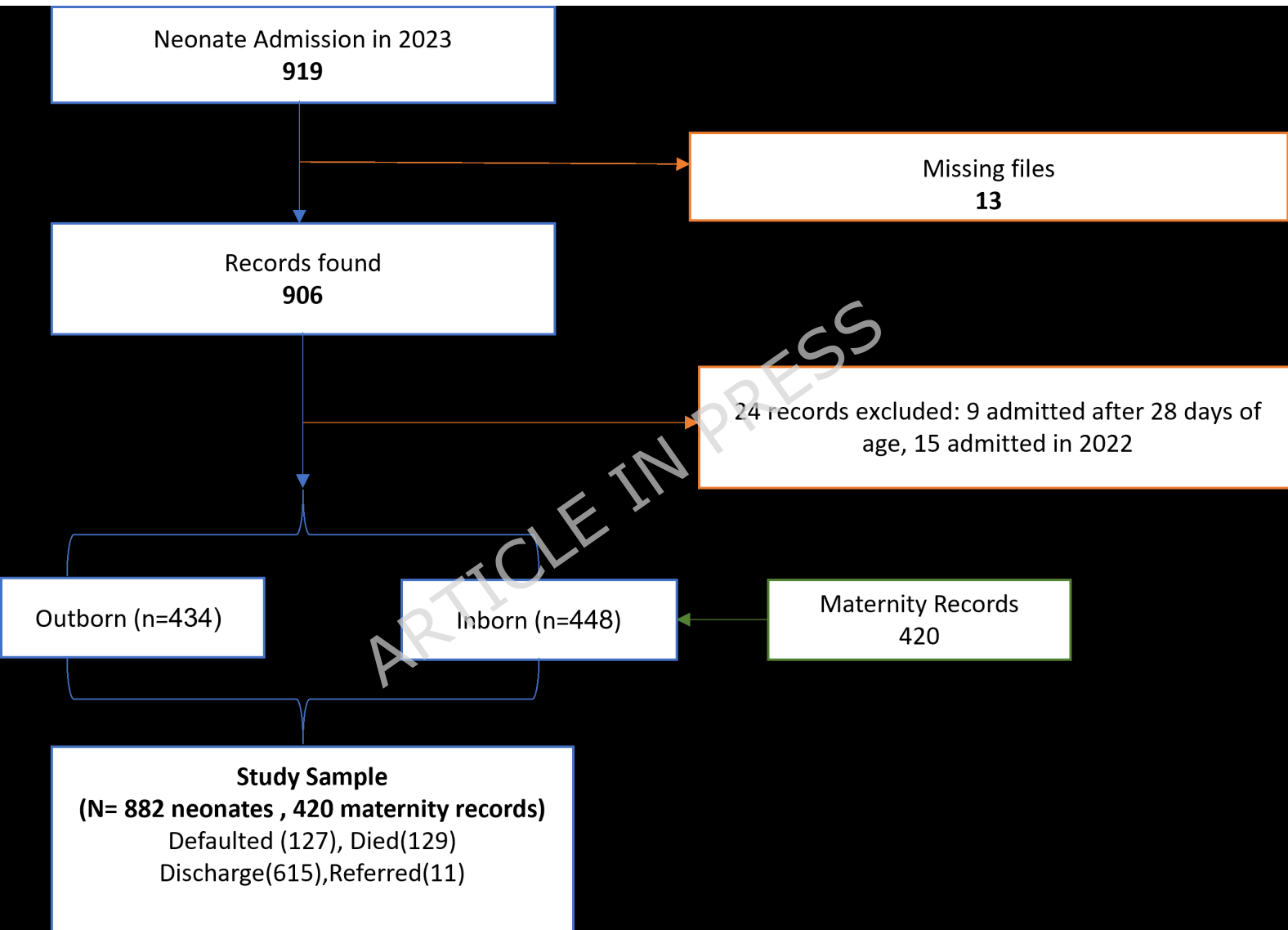
Characteristic	Discharge n=615 n(%)	In-Hospital Mortality n=129 n(%)	p-value¹
Initial Antibiotic Use	590 (96%)	126 (98%)	0.5
Ampicillin	550 (89%)	118 (91%)	0.5
Gentamicin	527 (86%)	107 (83%)	0.4
Cefotaxime	106 (17%)	48 (37%)	<0.001
Other Initial Antibiotics*	24 (4%)	10 (8%)	0.2
Overall Duration (days)	5.0 (4.0-7.0)	1.0 (0.0-3.0)	<0.001
Antibiotic Use after Modification	130 (23%)	49 (40%)	<0.001

Characteristic	Discharge n=615 n(%)	In-Hospital Mortality n=129 n(%)	p-value¹
Vancomycin	44 (7.2%)	35 (27%)	<0.001
Meropenem	56 (9.1%)	38 (29%)	<0.001
Other Modified Antibiotics**	30 (4.9%)	18 (14%)	—
Overall Duration (days)	7.0 (5.0-12.0)	1.0 (0.0-1.0)	<0.001

¹Pearson's Chi-squared test

*Includes cloxacillin, azithromycin, ceftriaxone, metronidazole, and other rarely used initial antibiotics.

**Includes cloxacillin, azithromycin, metronidazole, ceftriaxone, and other rarely used modified antibiotics



Forest Plot of Adjusted Odds Ratios

