Magnitude and Predictors of Death among Neonates with Congenital Anomalies at Neonatal Intensive Care Unit of a Tertiary Referral Hospital in Addis Ababa: A Cross-Sectional Analytical Study

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THESIS

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I, Addis Habtamu, want to make it clear that this research thesis is my own work and I have done it with the right guidance and supervision. Unless I've given credit where it's due in the text, this work hasn't been submitted to any institution to get any kind of academic qualification.

I state that this thesis is my own original work and does not include any material that has been previously published or written by someone else except those where proper citation and reference was given.

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Acronyms

ANC	Antenatal Care
AOR	Adjusted Odds Ratio
APGAR	Appearance, Pulse, Grimace, Activity, Respiration (score)
CI	Confidence Interval
COR	Crude Odds Ratio
GA	Gestational Age
ICU	Intensive Care Unit
LBW	Low Birth Weight
NPO	Nothing Per Oral
NICU	Neonatal Intensive Care Unit
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
WHO	World Health Organization
UNICEF	United Nations International Children's Emergency Fund
UN IGME	United Nations Inter-agency Group for Child Mortality Estimation
SDG	Sustainable Development Goals

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ABSTRACT

Background: Congenital anomalies are a major reason newborns die, especially in poorer countries. Ethiopia is seeing more of these cases, but hospitals here still lack solid data on which affected babies are most likely to die.
Objective: To assess the magnitude and maternal and neonatal factors associated with neonatal death among neonates with congenital anomalies admitted to a tertiary hospital.

Methods: An institution-based cross-sectional study was conducted among neonates diagnosed with congenital anomalies and admitted to the neonatal intensive care unit (NICU). Data were extracted from medical records of patients using a structured questionnaire. Descriptive statistics were used to summarize maternal and neonatal characteristics. Binary logistic regression was performed to identify factors associated with neonatal death. Crude odds ratios (COR) and adjusted odds ratios (AOR) with 95% confidence intervals (CI) were computed. Variables with $P<0.05$ in the multivariable analysis were considered statistically significant.

Results: Several maternal and neonatal factors achieved significant associations with neonatal death in crude analysis, including prematurity, low five-minute APGAR score, single congenital anomaly, absence of referral delay, fewer medical interventions, and prolonged nothing per os (NPO) status. After multivariable adjustment, prolonged NPO status for more than 24 hours (AOR = 0.32, 95% CI: 0.12–0.87) compared to being NPO for less than 24 hours, shorter length of hospital stay of <1 day (AOR = 17, 95% CI: 3.37–86.2), 1–16 days (AOR = 4.6, 95% CI: 1.79–11.8) more than 16 days, maternal age of 18-34 years (AOR = 0.39, 95% CI:0.17-0.88), compared to maternal age greater than 34 years, and primary education status (AOR =4.09,95% CI:1.52-10.97) compared to educational level of college and above were independently associated with neonatal mortality. Neonates hospitalized for longer than 176 days had an improved survival.

Conclusion: Babies who went without oral feeding for over a day, those who died very early in their hospital stay, and those whose mothers were under 34 or had little education — these were the groups with the highest death risk.

Keywords: Congenital anomalies, neonatal death, predictors, neonatal intensive care, Ethiopia.

1. Background

A baby's first month—the first 28 days—is when they're most likely to die. In 2023, about 2.3 million newborns died worldwide. That's roughly 6,300 every single day. Here's a shocking number: those deaths made up 47% of all deaths in children under five. The global neonatal mortality rate (NMR) has dropped from 37 per 1,000 live births in 1990 to 17 per 1,000 in 2023 [1]. So yes, we've made progress. But 17 is still too high.

Where you're born still matters enormously. Sub-Saharan Africa and South Asia have the worst rates—26 and 22 per 1,000, respectively, as of 2023. A baby in sub-Saharan Africa is ten times more likely to die in the first month than one born in a rich country. South Asia is eight times higher. And the gap is even wider if you compare the worst country to the best—the risk is 65 times higher.

Most deaths (nearly three-quarters) happen in the first week. A huge chunk occurs in the first 24 hours. What kills these babies? Prematurity, birth complications (asphyxia, trauma), infections, and congenital anomalies. Together, they're the top killers of kids under five. Yes, deaths from these causes have dropped since 2000, but they still make up the same large share of the problem [2].

Congenital anomalies—birth defects—are structural or functional problems that start before birth. You can spot them prenatally, at delivery, or sometimes later in infancy. The WHO says these conditions are a major driver of newborn deaths, especially in low- and middle-income countries where early diagnosis, surgery, and ICU care are hard to come by [3,4].

Here in Ethiopia, neonatal mortality is still a serious public health issue. The NMR was about 28 deaths per 1,000 live births in 2022 [5]. Congenital anomalies play a big role in that. A recent systematic review estimated that roughly 2% of Ethiopian newborns have a congenital anomaly, with neural tube defects being the most common [6]. That's a lot of affected families.

Hospital studies across Ethiopia consistently show that congenital anomalies take up a notable share of NICU admissions and deaths. The reported prevalence varies—from about 1% in some referral hospitals to over 8% in selected zones [7]. That variation probably reflects differences in patient mix, diagnostic capacity, and local referral patterns. Either way, congenital anomalies put a heavy load on neonatal services, especially at referral hospitals that get the most severe cases.

While the existing Ethiopian studies have established the presence of congenital anomalies among newborns, most have focused on hospital prevalence estimates and selected maternal or perinatal factors, with limited emphasis on clinical outcomes and determinants of death within tertiary referral settings. Several local isolated studies have explicitly recommended the generation of more comprehensive, facility-based evidence to better understand the clinical course and outcomes of neonates with congenital anomalies, particularly in hospitals managing complex referrals [6–7].

Tertiary referral hospitals such as Tikur Anbessa Specialized Hospital (TASH) receive neonates with severe and complicated congenital anomalies from across the country, making them critical settings to examine outcome patterns and associated predictors. Evidence generated from such centers reflects not only local service delivery, but also broader national referral practices and health system performance. Studies from Ethiopian referral hospitals have highlighted the need for outcome-oriented research to inform clinical decision-making, improve prioritization of care, and support planning of neonatal and surgical services [7].

Therefore, conducting a study focused on neonatal outcomes and associated factors among neonates with congenital anomalies in a tertiary referral hospital setting is justified to provide context-specific evidence that complements existing prevalence data and supports informed clinical and health system planning.

2. Problem statement and significance of the study

2.1 Problem Statement

Here's what we see every day at Tikur Anbessa Specialized Hospital (TASH): neonates with congenital anomalies come in, we try everything, and many still die within days. It's frustrating. Globally, about 2.3 million newborns die each year in the first month, and congenital anomalies are consistently among the top four causes—along with prematurity, birth complications, and infections [8].

The death toll is worst in low-income settings, especially sub-Saharan Africa, where the NMR is around 27 per 1,000 [8]. That's a huge gap compared to rich countries.

What does the evidence from Africa tell us? A systematic review found a pooled prevalence of congenital anomalies of about 23.5 per 1,000 births (2.35%), though it varies by country and region [9]. We don't have great outcome data from many low-resource settings, but what we do have suggests congenital anomalies cause a lot of illness and death. The problem is made worse by late hospital arrival, lack of prenatal diagnosis, not enough surgical capacity, and limited rehabilitation services.

In Ethiopia, we've reduced under-five mortality quite a bit. But neonatal mortality has been slower to drop. And we honestly don't have good population-level data on how much congenital anomalies contribute to the problem. At TASH—the country's main referral center for neonatal surgery and intensive care—we don't have solid numbers on the burden, predictors of death, or modifiable factors.

Without that evidence, designing targeted interventions, allocating resources wisely, and writing good clinical guidelines is nearly impossible. That's why I did this study: to generate local data that can inform clinical practice, guide health policy, and ultimately help more of these babies survive.

2.2 Significance of the Study

Babies with congenital anomalies need early diagnosis, specialized newborn care, and often surgery. All of which are hard to come by in Ethiopia. So preventable deaths keep happening because of late referrals, missed early detection, and not enough ICU capacity. That's hard on families and hard on the teams trying to help.

Hospital studies in Ethiopia have already shown that many newborns with congenital anomalies die. Especially those with neural tube defects and heart problems. What's frustrating is that some of these conditions are treatable. But by the time babies get to us, it's often too late [9–11].

Here's the problem: research on this topic in Ethiopia is scattered and incomplete. And at tertiary referral centers like Tikur Anbessa Specialized Hospital (TASH), where the sickest and most complex cases end up, we have even less evidence.

So I designed this study to fill that gap. I wanted to find out how many of these babies actually die and why. My hope is that clinicians, surgeons, and hospital administrators can use this evidence to make better decisions, use their limited resources more wisely, and improve the quality of neonatal care.

On a broader level, these findings can help Ethiopia move toward Sustainable Development Goal 3.2 , ending preventable newborn deaths by 2030 [12]. I also hope policymakers will use this evidence to strengthen referral systems, improve access to specialized care, and ultimately help more of these vulnerable babies survive.

3. Literature review

Newborn deaths are still a huge global problem. They make up nearly half of all deaths in children under five, even though we've made real progress in the last few decades [1,2]. Congenital anomalies, along with prematurity and infections are among the top killers, responsible for about 7% of newborn deaths worldwide. But the burden isn't spread evenly. Low- and middle-income countries take the hardest hit, where timely diagnosis, surgery, and intensive care are often not available [3,6,7].

Sub-Saharan Africa still has the worst rates. Why? Not enough trained staff, poorly equipped NICUs, late referrals, and too little surgical capacity [2,8]. In 2023, the region's newborn death rate was around 26 per 1,000 live births, much higher than in wealthy countries [2,8]. Studies from the region show that late arrival, weak NICU infrastructure, and limited surgery all lead to worse outcomes for babies with congenital anomalies [9].

Now let me zoom in on Ethiopia. Newborn death rates here are still critically high, about 27 to 28 per 1,000 live births in 2022 [5,6]. Congenital anomalies are an increasingly recognized part of that problem. A systematic review of Ethiopian studies found that roughly 2% of newborns have a congenital anomaly, with neural tube defects being the most common [6]. But here's the

catch: hospital studies show huge variation — from 1% in some referral hospitals to over 8% in others [7]. That variation probably reflects differences in who comes through the door, how we diagnose them, and what resources we have.

So we know congenital anomalies exist in Ethiopia. We even have some prevalence numbers. But most studies stop there, they focus on maternal risk factors and simple counts, without digging into clinical outcomes or what actually predicts death in tertiary referral hospitals [6,7]. A few retrospective studies from TASH and other referral hospitals have pointed to important predictors: low birth weight, prematurity, type of anomaly, delayed referral, and timing of surgery [10,11]. Multi-center studies also highlight system-level factors like NICU availability, surgical capacity, and maternal health [7].

Although the prevalence of congenital anomalies has been documented, most Ethiopian studies have focused on maternal or perinatal risk factors and descriptive prevalence estimates, with limited attention given to clinical outcomes and predictors of mortality in tertiary referral settings [6,7]. Retrospective studies from TASH and other referral hospitals have identified important predictors of mortality, including low birth weight, prematurity, type of anomaly, delayed referral, and timing of surgical intervention [10,11]. In addition, multi-center studies highlight the influence of system-level factors such as NICU availability, limited surgical capacity, and maternal health conditions on neonatal outcomes [7].

Despite these findings, comprehensive analyses incorporating broader clinical, socio-demographic, and health system–level predictors remain limited in Ethiopia. Most available studies are retrospective in nature, include relatively small sample sizes, or focus on restricted variables. In particular, the role of modifiable factors such as antenatal diagnosis, timing of referral, and NICU preparedness has not been sufficiently explored within the context of major tertiary referral centers, including Tikur Anbessa Specialized Hospital (TASH).

This study therefore will to address these gaps by assessing the magnitude and predictors of mortality among neonates with congenital anomalies admitted to the NICU at TASH. Identifying both clinical and system-level determinants will generate actionable evidence to inform targeted interventions, strengthen NICU planning, and improve early detection and referral strategies within the Ethiopian health system.

4. Objectives of the study

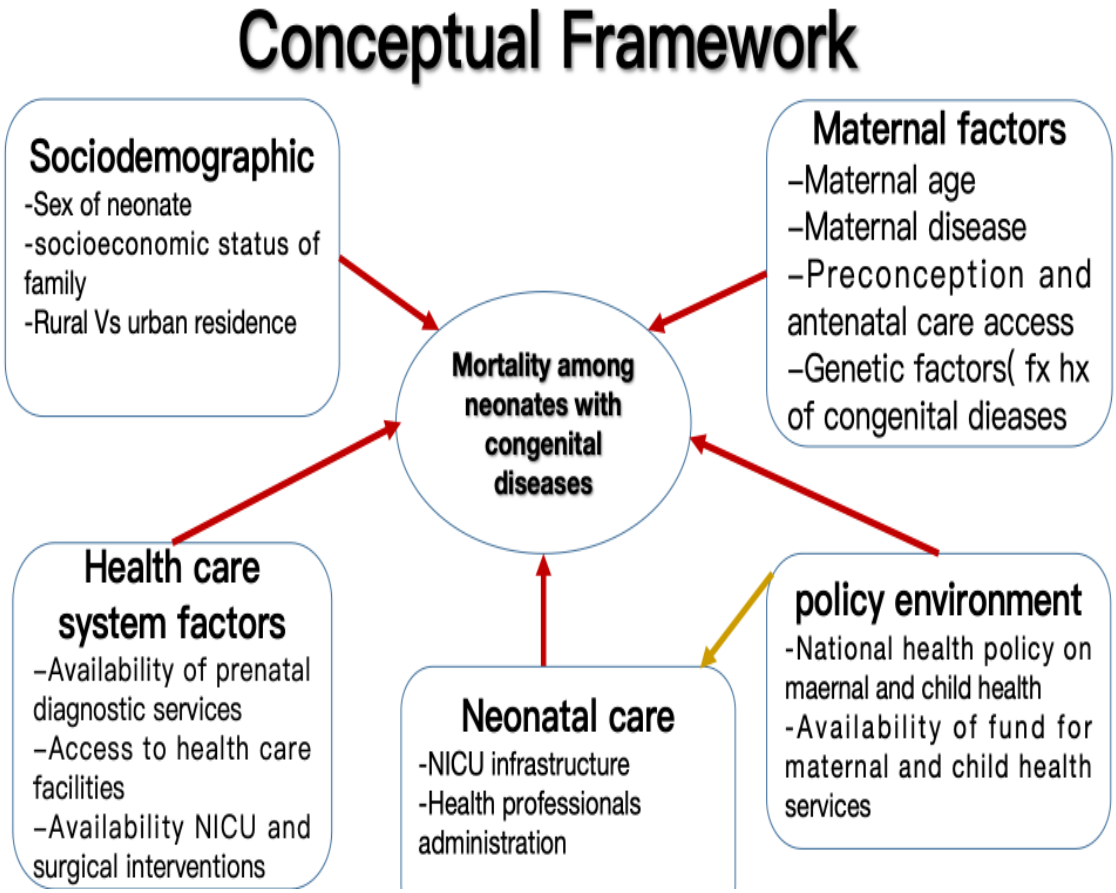
4.1 General Objective:

To determine the magnitude and predictors of death among neonates with congenital diseases admitted to the NICU at TASH in Addis Ababa.

4.2 Specific Objectives:

- To estimate the proportion of death among neonates with congenital diseases admitted to the NICU of TASH
- To identify clinical and sociodemographic factors associated with death among neonates with congenital diseases

5. Conceptual frame work



6. Materials and Methods

6.1 Study Setting

This study was conducted at Tikur Anbessa Specialized Hospital (TASH), the largest tertiary referral and teaching hospital in Ethiopia. TASH serves as a national referral center for high-risk obstetric cases and neonates with complex medical and surgical conditions, including congenital anomalies. It receives referrals from across Addis Ababa and other regional states.

1. Health Care System Context

Prenatal Diagnostic Services:

In Ethiopia, most women can't get advanced prenatal screening. Yes, ANC coverage has gotten better. But detailed anomaly scans, fetal echocardiography, genetic testing, and in-utero procedures? Not widely available — especially outside Addis.
As a result, many congenital anomalies are either undiagnosed antenatally or detected late in pregnancy, limiting opportunities for early referral, planned delivery in equipped centers, and timely surgical intervention.

Referral systems from peripheral health facilities to tertiary centers such as TASH are often delayed due to:

- Geographic barriers
- Transportation challenges
- Limited diagnostic capacity at primary and secondary facilities

These factors may contribute to delayed presentation and increased severity at admission.

2. Neonatal Care Capacity at TASH

The Neonatal Intensive Care Unit (NICU) at TASH is one of the few centers in the country managing critically ill neonates with congenital anomalies requiring advanced medical and surgical care.

At the time of the study:

- The NICU had 43 neonatal beds
- 4 functional incubators
- 1 functional mechanical ventilator
- X-ray services were not functional on the NICU floor
- Staffing included:
    - One Year-2 pediatric resident responsible for close clinical follow-up of critically ill neonates
    - 3–4 nurses per shift for critical side
    - Pediatric surgical team consisting of:
        - 1–2 senior residents
        - 3–4 junior residents
        - Surgical team rounds were conducted in the morning and upon consultation

Although the NICU serves as a tertiary-level center, resource limitations may influence neonatal outcomes, particularly for neonates with complex congenital anomalies requiring:

- Mechanical ventilation
- Advanced imaging
- Urgent surgical intervention
- Continuous multidisciplinary monitoring

We have only one working ventilator for way too many sick babies. That means some neonates with breathing problems don't get the support they really need. Additionally, the absence of functional bedside imaging may delay diagnosis and monitoring.

Furthermore, while a pediatric surgical team is available, most surgical neonates require close and frequent postoperative evaluation. However, surgical follow-up is dependent on consultation and availability, which may affect timely decision-making in critically ill neonates.

None of this is unique to us — it's what happens in most low-income countries. A baby's chance of surviving depends not just on what anomaly they have, but on whether the health system can actually handle the case.

3. Neonatal Care at Referring Facilities

Prior to admission to TASH, many neonates are delivered and initially managed in peripheral health facilities with limited:

- Neonatal resuscitation capacity
- Surgical stabilization capacity
- Mechanical ventilation availability
- Advanced diagnostic imaging

Delayed referral, suboptimal stabilization before transfer, and prolonged transport time may increase the risk of mortality among neonates with congenital anomalies.

4. Policy and Environmental Context

Ethiopia has implemented national strategies to improve maternal and child health outcomes under the Federal Ministry of Health's Maternal and Child Health (MCH) framework. While significant progress has been made in reducing under-five and neonatal mortality, specialized care for congenital anomalies remains resource-intensive.
Budget allocation for maternal and child health prioritizes:

- Antenatal care coverage
- Skilled birth attendance
- Essential newborn care
- Prevention of infectious causes of neonatal mortality

However, high-cost neonatal intensive care services and pediatric surgical infrastructure remain limited in number and concentrated in tertiary centers such as TASH. This imbalance between referral burden and available critical care resources may influence survival outcomes for neonates with congenital anomalies.

6.2 Study Design

A hospital-based cross-sectional study design was employed to assess the magnitude and clinical predictors of death among neonates with congenital anomalies and admitted to the

TASH NICU during the study period. The data was collected retrospectively from the medical records of patients admitted to the NICU.

6.3 Source Population

The source population includes all neonates admitted to the NICU at TASH.

6.4 Sampling Frame

The NICU admission logbook will be used as the sampling frame.

6.5 Study Subjects

The study population consists of neonates diagnosed with congenital anomalies and admitted to TASH NICU.

6.6 Inclusion and Exclusion Criteria

6.6.1 Inclusion Criteria

- Neonates diagnosed with one or more congenital anomalies.
- Neonates with medical records with documented outcomes (discharged alive or died).

6.6.2 Exclusion Criteria

- Neonates with congenital anomalies who were referred to other facilities
- Neonates with incomplete records, especially those missing key clinical data or outcome status.

6.7 Sampling Technique

All neonates with congenital anomalies admitted to the NICU, until the fulfillment of sample size and who meet the eligibility criteria will be included.

6.8 Sample Size Determination

Considering the patient flow, which was less than 300 over three years of time from the NICU HMIS documentation, patient flow was estimated to be 500 to have maximum estimate and sample size of 250 was attempted and sample of 235 was finally achieved in this study, and the sample size was deemed practical and sufficient.

Given heterogeneity of cases over several years and potential challenges with record completeness, including around half of the estimated population (~250 cases) was considered adequate to achieve the study objectives. This approach aligns with standard practices in hospital-based retrospective studies, ensuring both feasibility and statistical robustness.

6.9 Data Collection Tools and Procedures

Data was collected retrospectively using a structured checklist designed and deployed via *KoBo Toolbox*, a digital data collection platform. The checklist was designed based on literature review and NICU patient records and included:

- Maternal factors: age, parity, ANC visits, place of delivery
- Neonatal characteristics: sex, gestational age, birth weight, Apgar scores
- Type of congenital anomaly: anatomical or functional classification
- Clinical course: date of admission, time from birth to admission, complications, treatments offered (e.g., surgery, ventilation, antibiotics)
- Outcome: survived or died during NICU stay

Trained data collectors (pediatric residents or nurses) retrieved data from NICU admission records, patient charts, and discharge summaries. Data collection was supervised daily for accuracy and completeness by the principal investigator.

6.10 Operational Definitions

Congenital anomaly: A structural or functional abnormality present at birth, diagnosed clinically and/or through imaging and documented in the medical record.

Neonatal mortality (Outcome variable):
Death of a neonate with a diagnosed congenital anomaly during hospital admission within the neonatal period (0–28 completed days of life).

Preterm: Gestational age less than 37 completed weeks.

Term: Gestational age between 37 weeks and 41 weeks plus 6 days.

Post-term: Gestational age ≥ 42 completed weeks.

Low five-minute APGAR score: APGAR score between 0 and 6 at five minutes after birth.

Normal five-minute APGAR score: APGAR score between 7 and 10 at five minutes after birth.

Prolonged NPO: Nothing per oral (no enteral feeding) for more than 24 hours after admission.

Referral delay: Delay of more than 24 hours between birth and arrival at the tertiary hospital.

Multiple congenital anomalies:
Presence of two or more major congenital anomalies in the same neonate.

Length of hospital stay: Total number of days from admission to discharge or death.

6.11 Data Processing and Analysis

Collected data was exported to IBM-SPSS Mac version 25 for analysis.

- Descriptive statistics (frequencies, proportions, means or medians, and graphic presentation) was used to summarize demographic and clinical characteristics.
- Bivariable and multivariable logistic regression was used to identify potential predictors of neonatal mortality.
- Variables with $P<0.25$ in the bivariable analysis were included in the multivariable logistic regression model to adjust for confounders.
- A P-value < 0.05 was considered statistically significant, and adjusted odds ratios (AORs) with 95% confidence intervals was used to assess the precision of point estimates.

6.12 Data Quality Assurance

To ensure data quality:

- A pretest was conducted on 5% of medical records outside the study period.
- Daily review and cleaning of collected data was conducted by the principal investigator.
- Training was provided for data collectors on abstraction techniques and confidentiality.

6.13 Ethical Considerations

Ethical clearance was obtained from the Institutional Review Board (IRB) of Addis Ababa University, College of Health Sciences. An official permission letter was secured from TASH administration. Oral informed consent was obtained via phone form some of the questions. No names were collected, and data was used solely for research purposes.

6.14 Results Dissemination Plan

The results will be shared with all stakeholders, and will be using them to improve neonatal care, both within my institution and nationally. This may be in the form of presentation as appropriate to the residents, pediatricians, and neonatology consultants who are directly involved in managing neonates with congenital anomalies, and policy makers and program managers. A dedicated discussion session will be held with the team directly caring for neonates at the NICU. A manuscript/ manuscripts will be submitted to publication in peer-reviewed journal.

7. Results

7.1 Maternal socio-demographic and obstetric characteristics

A total of 235 mothers of neonates with congenital anomalies were included in the study. The mean maternal age was 28.02 years (SD ± 5.21).

The majority of mothers were urban residents (191; 81.3%), while 44 (18.7%) resided in rural areas. Regarding educational status, 28 (11.9%) mothers had no formal education. Among those who attended school, 15 (6.4%) had incomplete primary education and 44 (18.7%) had completed primary school. Secondary education was reported by 102 (43.4%) mothers, of whom 33 (14.0%) had incomplete and 69 (29.4%) had completed secondary school. Additionally, 23 (9.8%) mothers had college or diploma-level education, and 23 (9.8%) held a bachelor's degree.

In terms of parity, 100 (42.6%) mothers were primiparous, while 135 (57.4%) were multiparous. Almost all mothers, 230 (97.9%), had at least one antenatal care (ANC) follow-up, whereas 5 (2.1%) reported no ANC attendance. Among those who had ANC follow-up, the majority 215 (93.5%) attended 1–3 visits, 6 (2.6%) attended 4–7 visits, and 9 (3.9%) had eight or more visits. Regarding place of delivery, 48 (20.4%) mothers delivered at Tikur Anbessa Specialized Hospital (TASH). The remaining deliveries occurred at local health facilities, including 91 (38.7%) at health centers, 75 (31.9%) at primary or general hospitals, 7 (3.0%) at referral hospitals, and 8 (3.4%) at private maternal and child health centers. Home delivery was reported in 6 (2.6%) cases.

Maternal comorbidities during pregnancy were documented in 22 (9.4%) mothers, with diabetes mellitus, preeclampsia, and thyroid disorders being the most frequently reported conditions. The majority, 213 (90.6%), had no reported comorbidity. Drug exposure during pregnancy was reported in 11 (4.7%) mothers, mainly involving antibiotics, antihypertensive medications, and antithyroid drugs. No history of illicit drug or substance use was documented. A family history of congenital anomaly was reported in 6 (2.6%) cases; however, the reported anomalies differed from those observed in the study neonates.

Table 1: Maternal sociodemographic and clinical characteristics

Variable	Category	Frequency (n)	Percentage (%)
Maternal Age (years)	<18	5	2.1
	18–34	197	83.8
	≥35	33	14
Residence	Urban	191	81.3
	Rural	44	18.7
Educational Level	No formal education	28	11.9
	Incomplete primary	15	6.4
	Complete primary	44	18.7
	Incomplete secondary	33	14.0
	Complete secondary	69	29.4
	College/diploma	23	9.8
	Bachelor's degree	23	9.8
Parity	Primiparous	100	42.6
	Multiparous	135	57.4
ANC Attendance	Yes	230	97.9
	No	5	2.1
Number of ANC Visits	1–3	215	93.5
	4–7	6	2.6
	≥8	9	3.9
Place of Delivery	TASH	48	20.4
	Health centers	91	38.7
	Primary/General hospitals	75	31.9
	Referral hospitals	7	3.0
	Private centers	8	3.4
	Home	6	2.6
Maternal Comorbidities	Yes	22	9.4
	No	213	90.6
Drug Exposure During Pregnancy	Yes	11	4.7
	No	224	95.3
Family History of CA	Yes	6	2.6
	No	229	97.4

Binary logistic regression analysis was performed to assess the association between selected maternal factors and neonatal mortality among neonates admitted with congenital anomalies at Tikur Anbessa Specialized Hospital (TASH). Variables with p-value <0.25 in the bivariate (COR) analysis were entered into the multivariable logistic regression model to control for potential confounding. Crude Odds Ratios (COR) and Adjusted Odds Ratios (AOR) with 95% Confidence Intervals (CI) were computed. Statistical significance was declared at p-value <0.05.

In the bivariate logistic regression analysis, neonates born to mothers aged 18–34 years had significantly lower odds of mortality compared to mothers aged above 34 years (COR = 0.014, 95% CI: 0.18–0.83, p = 0.01).

After adjusting for other maternal factors in the multivariable model, maternal age 18–34 years remained significantly associated with neonatal mortality (AOR = 0.39, 95% CI: 0.17–0.88, p = 0.02), indicating that neonates born to mothers aged 18–34 years were 61% less likely to die compared to those born to mothers aged above 34 years.

Maternal age less than 18 years was not significantly associated with neonatal mortality in the adjusted model (AOR = 0.16, 95% CI: 0.01–2.1, p = 0.16).

In the crude analysis, urban residency was associated with lower odds of neonatal mortality compared to rural residency (COR = 0.38, 95% CI: 0.19–0.74, p = 0.01). However, after adjustment in the multivariable analysis, maternal residency was no longer statistically significant (AOR = 0.69, 95% CI: 0.32–1.47, p = 0.34), suggesting that the observed crude association was likely confounded by other maternal characteristics.
Maternal education level showed a significant association with neonatal mortality. In the crude analysis, mothers with primary education had higher odds of neonatal mortality compared to those with college education and above (COR = 4.2, 95% CI: 1.7–10.7, p = 0.00).

After controlling for other maternal variables, primary education remained an independent predictor of neonatal mortality (AOR = 4.09, 95% CI: 1.52–10.97, p = 0.00). This indicates that neonates born to mothers with primary education were approximately four times more likely to die compared to those whose mothers had college-level education or above.

Maternal education levels of no formal education (AOR = 1.39, 95% CI: 0.41–4.66, p = 0.59) and secondary school (AOR = 1.9, 95% CI: 0.76–4.9, p = 0.17) were not significantly associated with neonatal mortality after adjustment.

Place of delivery was significantly associated with neonatal mortality. In the crude analysis, delivery at TASH was associated with significantly lower odds of mortality compared to home delivery (COR = 0.09, 95% CI: 0.01–0.56, p = 0.01).

This association remained significant in the multivariable model (AOR = 0.07, 95% CI: 0.01–0.57, p = 0.01), indicating that neonates delivered at TASH were 93% less likely to die compared to those delivered at home.

Delivery at other health facilities showed reduced odds of mortality in the adjusted model (AOR = 0.16, 95% CI: 0.02–1.18), but this association did not reach statistical significance (p = 0.07).

7.1.1 Summary of Independent Predictors

After adjustment for confounders, the following maternal factors were independently associated with neonatal mortality among neonates with congenital anomalies at TASH:

- Maternal age 18–34 years (protective)

- Primary level maternal education (increased risk)
- Delivery at TASH (protective)

Maternal residency and other education categories were not independently associated with neonatal mortality.

Table 2 : Crude and Multivariable Logistic Regression Analysis of maternal factors associated with Neonatal death

Variable	Category	COR (95% CI)	*P*-value	AOR (95% CI)	*P*-value
Maternal age	Less than 18	0.27(0.027-2.64)	0.26	0.16(00.01-2.1)	0.16
	18 to 34 years	0.014(0.18-0.83)	0.01	0.39(0.17-0.88)	0.02
	Above 34 years(Ref)	1	-	1	-
Maternal residency type	Urban	0.38(0.19-0.74)	0.01	0.69(00.32-1.47)	0.34
	Rular(Ref)	1	-	1	-
Maternal education level	No formal education	1.6(0.50-4.98)	0.43	1.39(0.41-4.66)	0.59
	Primary school	4.2(1.7-10.7)	0.00	4.09(1.52-10.97)	0.00
	Secondary school	1.7(0.71-4.12)	0.23	1.9(0.76-4.9)	0.17
	College and above(Ref)	1	-	1	-
Place of delivery	TASH	0.09(0.01-0.56)	0.01	0.07(0.01-0.57)	0.01
	Other health facility	0.24(0.04-1.36)	0.12	0.16(0.02-1.18)	0.07
	Home(Ref)	1	-	1	-

7.2 Neonatal Characteristics

A total of 235 neonates with congenital anomalies admitted to TASH NICU during the study period were included in the analysis.

Table 3: Clinical characteristics of neonates with congenital anomalies

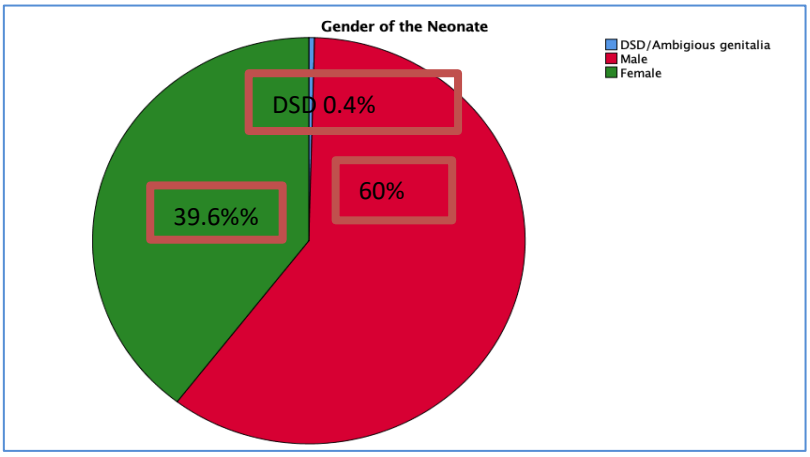
Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	141	60.0
	Female	93	39.6
	DSD	1	0.4
Gestational Age	Preterm (<37 weeks)	35	14.9
	Term (37–41+6 weeks)	178	75.7
	Post-term (≥42 weeks)	10	4.3
	Unknown	12	5.1
Age at Admission	<24 hours	104	44.3
	24–72 hours	79	33.6
	>72 hours	52	22.1
5-minute APGAR Score	Unknown but cried	73	31.1

	Unknown, did not cry	3	1.3
	Normal (7–10)	151	64.3
	Low (0–6)	8	3.4
Mode of Delivery	SVD	146	62.1
	Cesarean section	84	35.7
	Instrumental	5	2.1
Intrapartum Complications	Yes	142	60.4
	No	93	39.6
Number of CAs	One	181	77.0
	More than one	54	23.0
Antenatal Diagnosis	Yes	79	33.6
	No	156	66.4
Delay in Referral (>24 hrs)	Yes	128	54.5
	No	107	45.5
NICU Interventions	None	50	21.3
	1–3	69	29.4
	>3	116	49.4
NPO >24 hours	Yes	89	37.9
	No	146	62.1
Length of Hospital Stay	Less than 1 day(25^{th} centile)	65	27.7
	Between 1 and 16 days(25^{th} to 75^{th} centile)	116	49.4
	Above 16 days (75^{th} centile)	54	23
Types of Congenital Anomalies	Gastrointestinal	121	51.5
	Genitourinary	35	14.9
	Cardiovascular	23	9.8
	Chromosomal	22	9.4
	Musculoskeletal	12	5.1
	Nervous system	7	3.0
	ENT	9	3.8
	Orofacial	3	1.3
	Others	3	1.3
Outcomes	Discharged cured	34	14.5
	Discharged improved	79	33.6
	Discharged same condition	52	22.1
	Died	70	29.8
Causes of Death	Infection-related	36	15.3
	CA-related	24	10.2
	Metabolic	4	1.7
	Surgery-related	2	0.9
	Limited NICU resources	4	1.7

The total duration of hospital stay ranged from 0 to 80 days**,** with a standard deviation of 13.8 days**.** Range suggests variability in admission course.

Sex and Gestational Age:

Among the neonates, 141 (60.0%) were male and 93 (39.6%) were female, while one neonate (0.4%) had a disorder of sex development (DSD). Gestational age was unknown for 12 (5.1%) neonates. Of the remaining neonates, 35 (14.9%) were preterm (gestational age <37 weeks), 178 (75.7%) were term (37 weeks to 41 weeks + 6 days), and 10 (4.3%) were post-term (≥42 weeks).



Fugure 1: Sex distribution of neonates with congenital anomalies

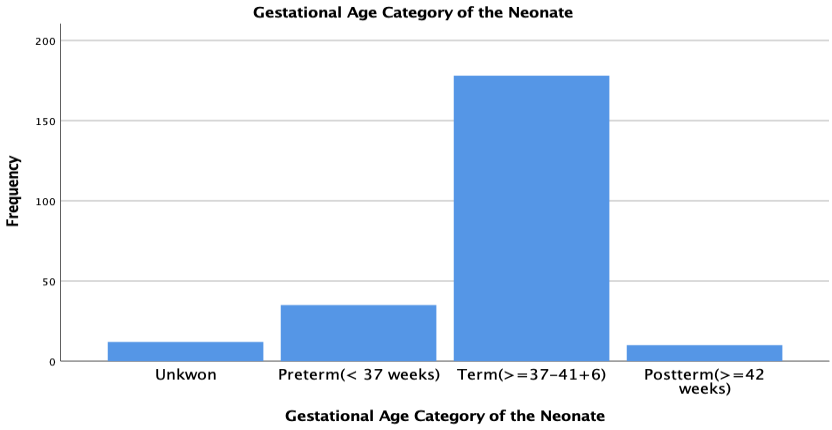


Figure 2: Gestational age distribution of neonates with congenital anomalies

Apgar Score and Mode of Delivery:

Regarding the 5-minute APGAR score, 73 (31.1%) neonates had unknown scores but cried immediately after birth, while 3 (1.3%) had unknown APGAR scores and did not cry immediately. A normal 5-minute APGAR score (7–10) was documented in 151 (64.3%) neonates, whereas 8 (3.4%) had a 5-minute APGAR score ≤6.

Most neonates were delivered by spontaneous vaginal delivery (SVD) (146; 62.1%), followed by cesarean section (84; 35.7%), and instrumental delivery (5; 2.1%).

Intrapartum Complications:

Intrapartum complications were documented in 142 (60.4%) deliveries, including fetal distress and abnormal labor patterns.

Diagnosis, Referral, and Admission:

More than one congenital anomaly was present in 54 (23.0%) neonates. Antenatal diagnosis of congenital anomalies by ultrasound was made in 79 (33.6%) neonates among mothers who had ANC follow-up.

Delayed referral (>24 hours after birth) to TASH occurred in 128 (54.5%) neonates. The main reasons for delay were unrecognition of the congenital anomaly by health professionals (65; 27.7%), parent-related factors (34; 14.5%), including lack of awareness of the condition, and logistical challenges (29; 12.3%), such as lack of transportation and security issues.
NICU Stay and Interventions

During NICU admission, 50 (21.3%) neonates received no interventions, 69 (29.4%) received one to three interventions, and 116 (49.4%) received more than three interventions. Interventions included surgery, antibiotic therapy, intravenous fluids, and supportive care such as suctioning, oxygen supplementation, and mechanical ventilation.

A total of 89 (37.9%) neonates were kept nil per os (NPO) during their NICU stay. No neonate received parenteral nutrition, according to medical records.

Types of Congenital Anomalies:

Based on WHO congenital anomaly categories, the most common anomalies were gastrointestinal anomalies (121; 51.5%), followed by genitourinary anomalies (35; 14.9%), cardiovascular anomalies (23; 9.8%), chromosomal anomalies (22; 9.4%), musculoskeletal anomalies (12; 5.1%), nervous system anomalies (7; 3.0%), ENT anomalies (9; 3.8%), orofacial anomalies (3; 1.3%), and other anomalies (3; 1.3%).

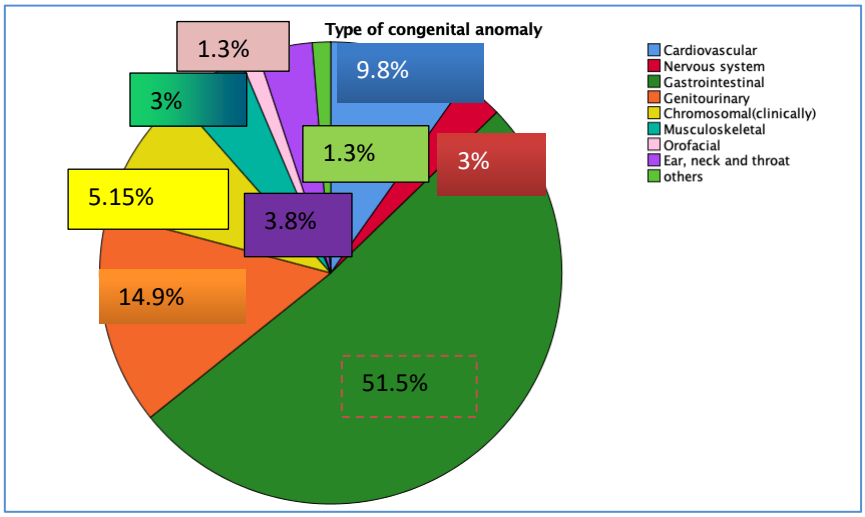


Figure 3: Distribution of types of congenital anomalies

Timing of Admission and Surgery:

The median age at admission was 34 hours (mean 59 hours, SD ±78). Among the 95 neonates who underwent surgical intervention, the median time from admission to surgery was 48 hours (mean 112 hours, SD ±129). Both variables were not normally distributed.

Clinical Outcomes:

Regarding clinical outcomes, 34 (14.5%) neonates were discharged cured, 79 (33.6%) were discharged with clinical improvement, and 52 (22.1%) were discharged with the same clinical condition, mainly stable medical cases scheduled for elective surgical follow-up. A total of 70 (29.8%) neonates died during hospitalization.

Causes of Death:

Among the 70 neonatal deaths, the immediate causes were infection-related in 36 (15.3%), congenital anomaly–related in 24 (10.2%), metabolic causes in 4 (1.7%), surgery-related complications in 2 (0.9%), and limited NICU resources in 4 (1.7%), including shortages of trained personnel and essential equipment such as mechanical ventilators.

Overall, the death rate among neonates with congenital anomalies admitted to TASH NICU was 29.8%. Bivariable and multivariable logistic regression analyses were performed to identify neonatal factors associated with the outcome. Variables with p-value <0.25 in bivariable analysis were entered into the multivariable logistic regression model.

Age at Admission:

In the crude analysis, neonates admitted within 24 hours of life had significantly lower odds of the outcome compared to those admitted after 72 hours (COR = 0.43, 95% CI: 0.21–0.89, p = 0.02). However, this association was not statistically significant after adjustment (AOR = 0.65, 95% CI: 0.06–7.64, p = 0.73). Admission between 24–72 hours was not significantly associated with the outcome in either crude or adjusted analysis.

Gestational Age:

Unknown gestational age (COR = 18, 95% CI: 1.65–196.3, p = 0.02) and preterm birth (COR = 9.5, 95% CI: 1.09–83, p = 0.04) were significantly associated with the outcome in bivariable analysis compared to post-term neonates (≥42 weeks). However, after multivariable adjustment, these associations were no longer statistically significant (preterm: AOR = 1.4, 95% CI: 0.1–19.3, p = 0.80; unknown GA: AOR = 21, 95% CI: 0.97–471.20, p > 0.05).

Five-Minute APGAR Score:

Neonates with normal APGAR score (7–10) had significantly lower odds of the outcome in crude analysis (COR = 0.18, 95% CI: 0.04–0.79, p = 0.024) compared to those with low APGAR (0–6). However, the association was not statistically significant in the adjusted model (AOR = 0.34, 95% CI: 0.05–2.11, p = 0.25).

Intrapartum Complications:

The presence of intrapartum complications was not significantly associated with the outcome in both crude and adjusted analyses.

Type of Congenital Anomaly:

None of the specific types of congenital anomalies (cardiovascular, nervous system, gastrointestinal, genitourinary, chromosomal, musculoskeletal, orofacial, ENT) showed a statistically significant association with the outcome in the multivariable analysis.

Antenatal Diagnosis:

Neonates without antenatal diagnosis had borderline significance in crude analysis (COR = 1.88, 95% CI: 0.99–3.53, p = 0.05), but the association was not significant after adjustment (AOR = 1.49, 95% CI: 0.58–3.58, p = 0.41).

Number of Congenital Anomalies:

Neonates with a single congenital anomaly had lower odds of the outcome in crude analysis (COR = 0.47, 95% CI: 0.25–0.89, p = 0.02), but this was not significant after adjustment (AOR = 0.99, 95% CI: 0.40–2.47, p = 0.99).

Delay in Referral:

Absence of referral delay (>24 hours) was significantly associated with reduced odds of the outcome in crude analysis (COR = 0.49, 95% CI: 0.28–0.89, p = 0.019). However, the association lost statistical significance in multivariable analysis (AOR = 2.56, 95% CI: 0.27–24.9, p = 0.42).

Comorbidity:

Presence or absence of comorbidity was not significantly associated with the outcome.

Number of Medical Interventions:

Receiving 1–3 interventions was significantly associated with lower odds of the outcome in crude analysis (COR = 0.35, 95% CI: 0.18–0.68, p < 0.001), but this was not statistically significant after adjustment (AOR = 0.59, 95% CI: 0.19–1.78, p = 0.35).

NPO for More Than 24 Hours:

Neonates who were not kept NPO for more than 24 hours had significantly lower odds of the outcome in both crude (COR = 0.24, 95% CI: 0.13–0.44, p < 0.001) and adjusted analysis (AOR = 0.32, 95% CI: 0.12–0.87, p = 0.03) compared to those kept NPO for more than 24 hours.

Length of Hospital Stay:

Compared to neonates hospitalized for more than 16 days (>75th percentile):

- Neonates admitted for 1–16 days had significantly higher odds of the outcome (AOR = 4.6, 95% CI: 1.79–11.8, p < 0.001).
- Neonates hospitalized for less than 1 day had markedly increased odds of the outcome (AOR = 17, 95% CI: 3.37–86.2, p < 0.001).

7.1.2 Summary of Independent Predictors

After multivariable logistic regression analysis, the following factors remained significantly associated with the outcome:

- NPO >24 hours
- Length of hospital stay

All other neonatal factors lost statistical significance after adjustment.

Table 4: Crude and Multivariable Logistic Regression Analysis of neonatal factors associated with Neonatal death

Variable	Category	COR (95% CI)	P-value	AOR (95% CI)	P-value
Age at admission (In hours)	Less than 24 hours	0.43(0.21-0.89)	0.02	0.65(0.06-7.64)	0.73
	24 to 72 hours	0.88(0.43-1.8)	0.73	1.17(0.40-3.39)	0.77
	Older than 72 hours (Ref)	1	-	1	-
Gestational age (In weeks)	Unkown	18(1.65-196.3)	0.02	21(0.97-471.20)	0.21
	Preterm(<37 weeks)	9.5(1.09-83)	0.04	1.4(0.1-19.3)	0.8
	Term (37-41weeks+6 days)	2.87(0.35-23.28)	0.33	2.7(0.27-27.3)	0.39
	>= 42 weeks (Ref)	1	-	1	-
Five minute APAGAR	Unknown but cried immediately after birth	0.42(0.09-1.89	0.26	0.5(0.07-3.55)	0.45
	Normal (7-10)	0.18(0.04-0.79)	0.02	0.34(0.05-2.11)	0.25
	Low (0-6) (Ref)	1	-	1	-
Presence of intrapartal complications	N0	0.69(0.39-1.23)	0.21	0.80(0.34-1.9)	0.63
	Yes (Ref)	1	-	1	-

Type of congenital anomaly	Cardiovascular	0.71(0.053-9.26)	0.79	1.2(0.03-51.6)	0.9
	Nervous system	0.33(0.01-8.180	0.50	3.6(0.04-304)	0.57
	Gastrointestinal	1.56(0.14-17.65)	0.72	1.4(0.04-51)	0.85
	Genitourinary	0.06(0.00-1.33)	0.07	0.12(0.00-10.9)	0.36
	Chromosomal	0.59(0.04-7.91)	0.69	1.05(0.03-44.8)	0.98
	ENT (Ear, nose and Throat)	1.00(0.06-15.98)	1.00	1.2(0.02-62.8)	0.93
	Others (Ref)	1	-	1	-
Antenatal diagnosis of congenital anomaly	N0	1.88(0.99-3.53)	0.05	1.49(0.58-3.58)	0.41
	Yes (Ref)	1	-	1	-
Number of congenital anomalies	One	0.47(0.25-0.89)	0.02	0.99(0.40-2.47)	0.99
	More than one (Ref)	1	-	1	-
Presence of delay in refferal (> 24 hours)	No	0.49(0.28-0.89)	0.02	2.56(0.27-24.9)	0.42
	Yes (Ref)	1	-	1	-
Presence of comorbidity	No	0.00(0.00-)	0.99	0.00(0.00-)	0.99
	Yes (Ref)	1	-	1	-
Number of medical interventions the neonates recieved	Recieved no interventions	0.00(0.00-)	0.99	0.00(0.00-)	0.99
	1-3 interventions	0.35(0.18-0.68)	0.00	0.59(0.19-1.78)	0.35
	>3 intervention (Ref)	1	-	1	-
Nothing per oral (NPO) more than 24 hours	No	0.24(0.13-0.44)	0.00	0.32(0.12-0.87)	0.03
	Yes (Ref)	1	-	1	-
Length of Hospital stay (In days)	Less than 1 day(25th centile)	0.79(0.32-2.01)	0.63	17(3.37-86.2)	0.00
	1 to 16 days(25th to 75th centile)	2.76(1.29-5.89)	0.01	4.6(1.79-11.8)	0.00
	More than 16 days (> 75th centile) (Ref)	1	-	1	-

8. Discussion

I looked at what factors — maternal, newborn, and health-system — were linked to death in babies with congenital anomalies at TASH. As infectious causes of newborn death go down around the world, congenital anomalies are becoming a bigger share of the problem [1,2,8, 11].

The World Health Organization recognizes congenital anomalies as a leading cause of neonatal mortality worldwide, particularly in low- and middle-income countries (LMICs), where access to specialized neonatal intensive care and pediatric surgical services remains limited [3].

In Ethiopia, systematic reviews and institutional studies confirm that congenital anomalies significantly contribute to neonatal morbidity and mortality [6,9]. While biological and clinical factors play a central role in determining survival, outcomes are also shaped by social determinants and structural health system capacity.

As a tertiary referral center, TASH manages neonates with complex medical and surgical conditions, often referred after delayed diagnosis or stabilization. Therefore, neonatal mortality in this setting reflects an interaction between maternal characteristics, neonatal clinical severity, referral pathways, and intensive care resource availability. The findings of this study highlight that neonatal survival among infants with congenital anomalies is influenced by both individual-level maternal factors and downstream clinical and health system determinants.

In this study, maternal age and maternal educational level demonstrated statistically significant associations with neonatal mortality in the multivariable analysis. This indicates that, beyond neonatal clinical severity, certain maternal sociodemographic characteristics independently influence survival outcomes.

Maternal factors:

Maternal Age:

Mothers aged 18–34 years had significantly lower odds of their baby dying. We've known for a long time that both very young and older mothers face higher risks. Older mothers have more chromosomal problems and congenital anomalies. Younger mothers often face poverty, less health knowledge, and delayed care [6,9]. Studies from other countries back this up [13,14]. In low-income settings, a mother's age can tell us about her access to antenatal care, her ability to make decisions, and when she gets referred to better hospitals.

In this study, the observed association suggests that maternal age may influence neonatal survival through mechanisms such as variations in antenatal care attendance, timeliness of anomaly detection, birth preparedness and complication readiness, health-seeking behavior and referral timing. Although congenital anomalies are structural conditions, survival after birth depends on early presentation and appropriate management. Therefore, maternal age may indirectly affect outcomes by shaping interaction with the health system.

Maternal Educational Level:

A mother's education level also mattered independently. This isn't surprising — education is a known social determinant of health. Systematic reviews from Ethiopia and across Africa show that less educated mothers have worse newborn outcomes: they use antenatal care less often,

spot danger signs later, and face more poverty [6,9]. Better-educated mothers seek care sooner, prepare better for birth, and deliver in places with skilled providers.

For congenital anomalies, early survival depends on recognizing complications quickly, getting referred on time, following medical advice, and talking effectively with providers. So maternal education likely helps mothers navigate the referral system and get specialized care. This tells me that reducing deaths from congenital anomalies isn't just about better ICUs and surgery — we also need to address social factors like maternal education.

Neonatal factors

Gestational Age:

Premature babies had higher death rates in my initial analysis, but that link disappeared after adjusting for other factors. Biologically, prematurity raises death risk because organs aren't fully developed. International studies show that being premature and having a congenital anomaly together make death even more likely [13,14]. One study found that congenital anomalies increase death risk even after accounting for gestational age [15]. Why did prematurity stop being significant in my adjusted model? Probably because other factors I measured — like NPO status and early death — captured the same severity. The wide confidence intervals also tell me I didn't have enough premature babies in my sample to be certain.

Five-Minute APGAR Score:

Babies with normal APGAR scores (7–10) had lower death rates in my crude analysis, but this didn't hold up after adjustment. A low APGAR score tells you the baby had a rough transition to life outside the womb. Large population studies have shown that low 5-minute APGAR scores strongly predict early newborn death, even in babies with congenital anomalies [16,17]. Ethiopian hospital studies found the same thing [7,8]. Why did APGAR lose significance after adjustment? Probably because it's not an independent predictor — it's a marker of how sick the baby already is, and other variables in my model captured that sickness better.

Antenatal Diagnosis:
In my crude analysis, babies without an antenatal diagnosis had a borderline higher risk of death. But after adjusting for other factors, it wasn't independently significant. Globally, finding anomalies before birth allows for planned delivery at a good hospital, early surgical planning, and immediate stabilization — all of which improve survival [3,18].

But here's the reality in Ethiopia. Most women don't have access to detailed anomaly scans or fetal echocardiography, especially outside Addis. And even when we do detect an anomaly before birth, the survival benefit is often lost because we just don't have enough surgical infrastructure or ICU capacity. That probably explains why antenatal diagnosis didn't show up as an independent predictor in my study.

Number and Type of Congenital Anomalies:

Babies with more than one anomaly had higher death rates in my initial analysis, but this didn't hold up after adjustment. Systematic reviews from Africa show that multiple anomalies mean worse survival — more complex physiology, harder surgeries [9]. Ethiopian studies on heart defects and neural tube defects found the same thing [10,11,12].

Why did it stop being significant in my model? Probably because I didn't have enough babies in each anomaly subgroup to be sure. The confidence intervals were wide, which tells me I need a larger sample to really know.

NPO Status (>24 Hours):

Babies kept NPO for more than 24 hours had much higher death rates. This was one of the strongest predictors in my study. What does NPO status tell us? Usually it means the baby has a gastrointestinal blockage, is unstable, is being prepared for surgery, or is simply getting sicker. Starting enteral feeding early is generally a sign the baby is stable and doing well [8]. So prolonged NPO is a red flag.

Length of Hospital Stay

Babies who stayed less than 1 day or 1–16 days had much higher death rates than those who stayed longer than 16 days. This isn't surprising — it just means babies who died, died early. Most deaths happened in the first few days. Ethiopian heart disease studies found the same thing: most deaths occur within the first week of admission [11,12]. Studies from across sub-Saharan Africa report that babies with severe anomalies die early, especially if surgery is delayed [9,20].

A longer hospital stay doesn't "protect" babies. It just means they survived the initial crisis.

Health System and Structural Context

A key strength of this study is the integration of structural health system context in interpreting neonatal mortality outcomes.

Prenatal Diagnostic and Referral Systems:

Yes, Ethiopia has improved antenatal care coverage [5]. But advanced screening for anomalies? Still very limited. So diagnoses are delayed, which means fewer planned deliveries at good hospitals and less surgical coordination [3]. Referral systems from small facilities are a mess — geographic barriers, no transport, poor diagnostic capacity at lower levels. African systematic reviews confirm that delayed referral and poor stabilization before transfer increase death risk for babies with anomalies [9,20].

NICU Capacity and Resource Constraints at TASH:

TASH is supposed to be the national referral center. But we operate with serious resource limits. One functional ventilator. Four incubators. No bedside X-ray. Managing congenital anomalies

often requires ventilation, urgent surgery, and constant multidisciplinary monitoring. In low-income settings, survival depends not just on what anomaly the baby has, but on whether the health system can actually handle the case [5,9]. We get more sick babies than we can manage with what we have. That imbalance almost certainly contributed to the early deaths I saw in this cohort.

Policy and Public Health Implications:

As infectious causes of neonatal death decline globally, congenital anomalies account for a growing proportion of neonatal mortality [1,2,8]. Achieving Sustainable Development Goal 3 requires addressing congenital anomaly–related mortality through strengthening prenatal detection systems, improving referral networks, expanding NICU capacity, increasing pediatric surgical infrastructure [5]. The findings of this study emphasize that clinical stabilization, early survival phase, feeding management, and system-level capacity are critical determinants of outcome in this setting.

Overall Interpretation:

Overall, this study demonstrates that mortality among neonates with congenital anomalies in a tertiary hospital in Ethiopia is primarily driven by clinical severity indicators, early critical illness, and health system limitations. Maternal factors were not independently associated with mortality after adjustment. Improving outcomes will therefore require a multilevel approach, including early detection, timely referral, strengthening NICU capacity, and improving pediatric surgical services.'

9. Strengths and Limitations

This study provides important institutional data on predictors of neonatal mortality among neonates with congenital anomalies. However wide confidence intervals indicate limited subgroup power, retrospective design may introduce documentation bias, and some anomaly categories had small cell counts, and despite these limitations, the study aligns with national and international evidence and highlights context-specific management challenges.

10. Conclusion and recommendation

Conclusion

This study looked at which maternal and newborn factors were linked to death in babies with congenital anomalies at a tertiary hospital. The bottom line: both matter.

Mothers aged 35 or older and those with little education had higher odds of their baby dying. That tells us that social and biological factors, but not just what's wrong with the baby, really matter.

Among newborn factors, two things stood out. Babies kept NPO (nothing by mouth) for more than 24 hours had higher death rates. So did babies with very short hospital stays. What does that mean? Early instability, feeding problems, and how sick the baby is right from the start are key. A short hospital stay basically means babies died early, most deaths happened in those first few days.

Now, some things showed up as risky in my initial analysis but didn't hold up after adjustment: being premature, having a low 5-minute APGAR score, no antenatal diagnosis, multiple anomalies, and delayed referral. Why did they lose significance? Because once I accounted for how sick the baby actually was at admission, those factors stopped being independent predictors. That tells me there's a complex interaction between a baby's baseline characteristics and what happens right after birth.

So here's the takeaway: in this setting, a newborn's chance of survival is shaped by both maternal vulnerability and how severe their early clinical condition is. If we want to save more of these babies and help Ethiopia reach Sustainable Development Goal 3, we need to invest in maternal education, identify high-risk pregnancies early, stabilize newborns promptly, support feeding, fix our referral systems, and expand specialized neonatal and surgical care.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

Clinical Recommendations

Strengthen Early Neonatal Stabilization
Since early clinical instability indicators (such as prolonged NPO status and short hospital stay) were associated with increased mortality, neonatal units should strengthen immediate post-admission stabilization protocols, improve early monitoring of high-risk neonates, implement standardized feeding initiation guidelines, enhance early detection of deterioration, and early stabilization within the first 24–72 hours should be prioritized, as this period appears critical for survival.

Improve Feeding Support and Nutritional Management
Given that prolonged NPO status was independently associated with mortality , early enteral feeding protocols should be strengthened where clinically appropriate, feeding intolerance should be promptly assessed and managed, surgical and medical teams should coordinate early nutritional planning, and feeding status should be used as an early clinical severity indicator in neonates with congenital anomalies.

Enhance Multidisciplinary Care
Management of congenital anomalies requires coordinated care. Hospitals need to strengthen collaboration between neonatologists, pediatric surgeons, anesthetists, and nursing staff,

conduct regular case reviews for neonatal deaths, and establish structured clinical pathways for common congenital anomalies.

Institutional and Health System Recommendations

Strengthen Referral Systems

Although referral delay was not independently significant after adjustment, early-phase mortality suggests the need to improve early identification and timely referral of neonates with congenital anomalies, strengthen communication between referring facilities and tertiary centers, and ensure availability of transport with neonatal stabilization capacity.

Improve Antenatal Care and Birth Preparedness

Even though antenatal diagnosis was not independently associated with mortality in this study, early detection remains critical. The health system need to expand access to quality obstetric ultrasound services, train providers in anomaly detection, and improve counseling and planned delivery at equipped facilities.

Expand Specialized Neonatal and Surgical Capacity

Given the increasing burden of congenital anomalies, the system needs to strengthen neonatal intensive care units (NICU), increase access to pediatric surgical services, improve availability of essential equipment and monitoring devices is warranted, and address congenital anomaly-related mortality is essential for achieving Sustainable Development Goal 3.

Policy-Level Recommendations

The system needs to integrate congenital anomaly surveillance into national newborn health strategies, strengthen national birth defect registries, include congenital anomaly management within maternal and child health policies, and allocate the required resources for early neonatal critical care services

Research Recommendations

Based on study limitations, there is a need to conduct prospective multicenter epidemiological studies to better determine independent predictors, investigate severity scoring systems for neonates with congenital anomalies, assess long-term survival and developmental outcomes, explore health system barriers contributing to early in-hospital mortality, and conduct studies with larger sample sizes may provide more precise estimates and narrower confidence intervals.

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12. Appendix

STUDY TITLE
Magnitude and Predictors of Death among Neonates with Congenital Anomalies at Neonatal intensive care unit, Tikur Anbesa Specialized Hospital (TASH), Addis Ababa : A Cross-sectional Study
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ETHICAL CLEARANCE
Approved by: Institutional Review Board (IRB), Addis Ababa University (Ref: AAU/IRB/2025/XYZ)
Permission Granted by: TASH Administration
CONFIDENTIALITY STATEMENT
All personal identifiers (name, medical record number, address) will be excluded. Data will be used solely for the research purposes and stored securely.
Purpose of the Questionnaire
This data collection tool is designed to systematically extract information from medical records of neonates admitted to the TASH NICU with congenital anomalies.
Its objectives are to:
Estimate the proportion of mortality among these neonates.
Identify clinical and sociodemographic predictors of death.

Why This Study Matters
Congenital anomalies contribute to 47% of neonatal deaths in Ethiopia (UNICEF 2023).
TASH is Ethiopia's largest referral center for critical neonatal anomalies, yet local evidence on predictors of mortality is limited.
Findings will guide clinical protocols, resource allocation, and national neonatal survival strategies.

Instructions for Data Collectors
Source: Extract data from NICU admission logs, patient charts, and discharge summaries.
Tool: Enter data digitally via KoBo Toolbox using this structured questionnaire.
Scope: Include neonates meeting all criteria:
Diagnosed with ≥1 congenital anomaly.
Admitted to TASH NICU during the study period.
Outcome documented (died/discharged alive).
Exclude: Referred cases or records missing key variables (e.g., birth weight, outcome).

Confidentiality Assurance
No patient identifiers will be recorded. Data will be anonymized and accessible only to the research team.
Contact for Clarification:
Dr. Addis Habtamu
Email: addis.habtamubekele@gmail.com t Phone: +251-923-478-321

I. Identification & Administrative Data
Medical record number:---------
Date of admission: ---------
Date of discharge/death: -------
2.Sociodemographic & Maternal Factors
Mother's age at birth------
Residence (urban/rural)-----
Education level & occupation-----
ANC
attendance (yes/no; number of visits)

Facility:
TASH
Health center
Private clinic
Place of delivery------
TASH
Other hospital
Health center
Home
Parity and birth order-----
Maternal comorbidities
yes (Specify)--
No---
Substance exposure during pregnancy (alcohol, khat, tobacco)
Neonatal Characteristics
Sex:
Male ----
Female---
5.2 Gestational age: _____ weeks
Preterm (<37 weeks) ---
Term (≥37 weeks) -----
5.3 Birth weight: _____ grams
Low birth weight (<2500g) ---
Normal---
5.4 Apgar score
1 min: _____
5 min: _____
6. Mode of delivery:
Vaginal ----
Cesarean---

7.Clinical Diagnosis & Anomaly Details
7.1 Type of anomaly
Cardiovascular ---
Neural tube defects ---
Gastrointestinal-----
Genitourinary-----
Chromosomal-----
Musculoskeletal------
Other-----
7.2 Number of anomalies
Single ----
Multiple---
7.3 Whether anomaly prenatally diagnosed
Yes ----
No---
.Clinical Course & Management
Time to admission: _____ hours (from birth to NICU admission)
Complications :
Sepsis (culture-confirmed)
Respiratory distress
Hypoglycemia (<40 mg/dL)
Hypothermia
Seizures
Necrotizing enterocolitis

Interventions received:
Mechanical ventilation
Surgery---- (specify type)
Antibiotics----
Blood transfusion
Time to surgery (if applicable): _____ days

9.Outcome
Survival status
Discharged alive ----
Died during NICU stay---
Date of outcome ----
Length of stay in NICU (in days)----

10.System-Level Factors
10.1 Delay factors:
10.1.1Delayed referral (>24h after birth)
yes
No
10.1.1.1 Lack of transport---
10.1.1.2 Financial barriers----

10.2 NICU resource gaps during stay
Ventilator unavailable---
Medication shortage----
Staff shortage----