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Determinants of congenital anomalies among newborns in public hospitals of Northern Ethiopia: case-control study design

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Congenital anomalies are structural or functional abnormalities that occur during intrauterine life and are major public health concern in low and middle income countries. Therefore, this study aimed to assess the determinants of congenital anomalies among newborns in public hospitals of northern Ethiopia. Case-control study design was conducted among 384 (77 cases and 307 controls) newborns in randomly selected public hospitals of Tigray region from April 1/2024 to July 30/2024. Data were collected through interviewer-administered, pretested, and structured questionnaires. Variables with a $p < 0.25$ in bivariable analysis were included in the multivariable analysis with set at $p < 0.05$. Folic acid supplementation (AOR = 0.30, 95%CI: (0.12–0.69), low birth weight (AOR = 4.17, 95% CI: 1.66–10.45), presence of medical illness during pregnancy (AOR = 6.07, 95% CI: 2.58–14.29), poor food consumption score (AOR = 3.07, 95% CI: 1.11–8.42), lack of nutritional counseling (AOR = 3.23, 95% CI: 1.50–7.04), inadequate additional food intake during pregnancy (AOR = 2.34, 95% CI:1.10–4.98) and alcohol consumption during pregnancy (AOR = 2.80, 95% CI: 1.30–6.08) were significantly associated with increased odds of congenital anomalies. Folic acid supplementation, nutritional counselling, enhancing maternal nutrition, early screening, and management of maternal illnesses along with promoting healthy diets and discouraging alcohol use are essential to reduce congenital anomalies.

Keywords Tigray, Ethiopia, Determinants, Congenital anomaly, Newborns

Abbreviations

AOR	Adjusted Odds Ratio
ANC	Antenatal Care
BSC	Bachelor of Science
CI	Confidence Interval
COR	Crude Odds Ratio
FCS	Food Consumption Score
SPSS	Statistical Package for Social Sciences
VIF	Variance Inflation Factor

Congenital anomalies are defects in structure, or function that arise during intrauterine life and can be detected during pregnancy, at birth or later in life[1]. Congenital anomalies are divided into three severity categories: minor, severe, and lethal. Major anomalies include both severe and lethal types[2]. About 6% of newborns worldwide are born with congenital anomalies, which result in 240,000 neonatal deaths and an additional 170,000 deaths among children under five[1,3]. Approximately 94% of severe congenital anomalies worldwide occur in low and middle income countries, where congenital anomalies are very common[2]. In Africa, the prevalence of congenital

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anomalies ranges from 2.04% to 5.58%[2,4,5]. Ethiopia is one of the sub-Saharan African countries severely affected by congenital anomalies with reporting rates of 0.38% to 4.1%[6–11]. Pre-war data indicated Tigray region had one of Ethiopia's highest rates of congenital anomalies at 3.13%[12]. Epidemiological data collected after the outbreak of war in Tigray showed a 2.62% prevalence of neural tube defects, indicating a substantial increase from pre-war levels which was 2.15%[12,13]. Congenital anomalies can lead to persistent cognitive and physical impairments, resulting in long-term socioeconomic burdens, care giver strain, and adverse psychological effects on families[8,14]. Several risk factors for congenital anomalies during pregnancy have been found through research; these risk factors can be classified as either modifiable (such as maternal alcohol consumption, periconceptional folic acid supplementation, exposure to pesticides, and exposure to radiation) or non-modifiable (such as family history of congenital anomaly, maternal age, and sex of the newborn). These include chromosomal abnormalities, environmental teratogens, maternal alcohol consumption, pesticides exposure, genetic predispositions, and nutritional deficiencies[8,11,15]. Targeted interventions like maternal and child vaccination, balanced parental nutrition, and periconceptional micronutrient supplementation (e.g., folic acid and vitamin B12) can prevent congenital anomalies[8,11]. The Ethiopian government has implemented several strategies to address congenital anomalies in Ethiopia. The interventions include; folic acid supplementation and food fortification[16], maternal health and antenatal care (ANC) programs[17], public awareness and health education[18], surveillance and data collection[16], and addressing environmental and nutritional risks[17,19]. However the war in Tigray severely disrupted the health care system, leading to; collapse of ANC services, destruction of health facilities and food insecurity and malnutrition[16,20].

Despite the serious public health consequences, no study has investigated the post-war determinants of congenital anomalies in public hospitals of the northern Ethiopia since the conflict ended. Modifiable risk factors, including malnutrition and gaps in prenatal care, were likely exacerbated by the systemic collapse of the healthcare infrastructure and a two year blockade (2020–2022) that prevented access to maternal care, prenatal supplements, and foods fortified with folate. Thus, the aim of this study was to assess the determinants of congenital anomalies among newborns in public hospitals of northern Ethiopia.

Methods

Study area and period

This study was conducted in public hospitals of Tigray, a northern Ethiopian region located approximately 780 km from Addis Ababa, Ethiopia's capital. Before the 2020–2022 war, Tigray had a population of 9.4 million and a total fertility rate of 4.6 children per woman[13]. A critical network for maternal and neonatal care was formed by the region's healthcare system, which included 14 hospitals, 170 health centers, and 552 health posts. Tigray's infrastructure and healthcare system suffered catastrophic damage during the active conflict period, which lasted from 2020 to 2022. Prenatal care and nutritional support programs were among the many services that were severely disrupted by the estimated 89% of health facilities that were looted, destroyed, or rendered inoperable[13].

The study was conducted from April 1, 2024, to July 30, 2024, after the end of the conflict.

Study design

A facility-based case control study design was implemented.

Source population

All mothers who had a pregnancy outcome (delivery or termination) at or after 12 weeks of gestation in the selected public hospitals of the Tigray region during the study period.

Study population

Cases All mothers who delivered or had a termination at ≥ 12 weeks of gestation where the newborn was diagnosed with a congenital anomaly in the selected hospitals during the study period.

Controls All mothers who delivered a newborn without any congenital anomaly at ≥ 12 weeks' of gestation in the same selected hospitals during the study period.

Eligibility criteria

Inclusion criteria

Cases All mothers who delivered or had a pregnancy termination at ≥ 20 weeks of gestation in which the fetus or newborn was diagnosed with a congenital anomaly. Diagnosis was made by a qualified physicians using prenatal ultrasound, postnatal clinical examination, and medical records, and congenital anomalies were classified according to WHO International Classification of Diseases 11th Revision (ICD 11).

Controls All mothers who delivered or had a pregnancy termination at ≥ 20 weeks of gestation in which the fetus or newborn had no diagnosed with congenital anomaly, as confirmed by physicians through prenatal and postnatal clinical examination and medical records, using ICD 11 classification. Controls were selected from the same health facilities and during the same time period as cases.

Exclusion criteria for cases and controls

The study excluded newborns whose mothers were unavailable or unable to be interviewed due to critical illness.

Sample size determination

The sample size was calculated by taking into account the multiple hypothesized risk factors that contribute to congenital anomaly. The sample size was determined using Epi Info software (version 7.2.5.0) employing the unmatched case-control study formula. Parameters for the calculation include a 95% confidence level, 80% statistical power, and a 4:1 control-to-case ratio. Exposure proportions were derived from a prior study in eastern Ethiopia[21], which reported 6.2% exposure among controls, 18.6% exposure among cases, and an odds Ratio of 4 with alcohol consumption identified as an exposure variable. Initial calculations yield 70 cases and 279 controls. To account for potential non-response, a 10% non-response rate was added; the final sample size becomes 384 (77 cases and 307 controls).

Sampling technique and procedure

Four hospitals operating under the interim government of the Tigray region were selected through a simple random sampling method: Adwa Hospital, Abyi-Adi Hospital, Wukro Hospital, and Quiha Hospital. The overall sample size of 384 (77 cases and 307 controls) was distributed proportionally to each chosen hospital according to the total number of deliveries recorded in the previous year. The distribution was as follows: Adwa Hospital (2,840 deliveries), Abyi-Adi Hospital (1,620 deliveries), Wukro Hospital (2,560 deliveries), and Quiha Hospital (2, 180 deliveries). This resulted in the following sample size allocations: Adwa Hospital (24 Cases, 95 controls), Abyi-Adi (14 cases, 54 controls), Wukro Hospital (21 cases, 85 controls), and Quiha Hospital (18 cases, 73 controls). Cases were enrolled consecutively, while controls were selected using the systematic random sampling technique. The sampling interval (K^{th}) was determined separately for each hospital by dividing the total number of deliveries in the previous year by the allocated sample size. The calculated sampling interval becomes approximately 30 for each hospital. This means every 30th newborn after a randomly selected starting point was included in the study (Fig. 1).

Operational definitions

Congenital anomaly A structural or functional abnormality present at birth affecting one or more organs or body systems, diagnosed by a physician during the antenatal period using ultrasound or at birth through clinical examination, and classified according to the WHO ICD 11.

Cases Mothers who delivered newborns with congenital anomaly affecting any body system, identified by a physician either during the antenatal period (through diagnostic imaging) or immediately after birth.

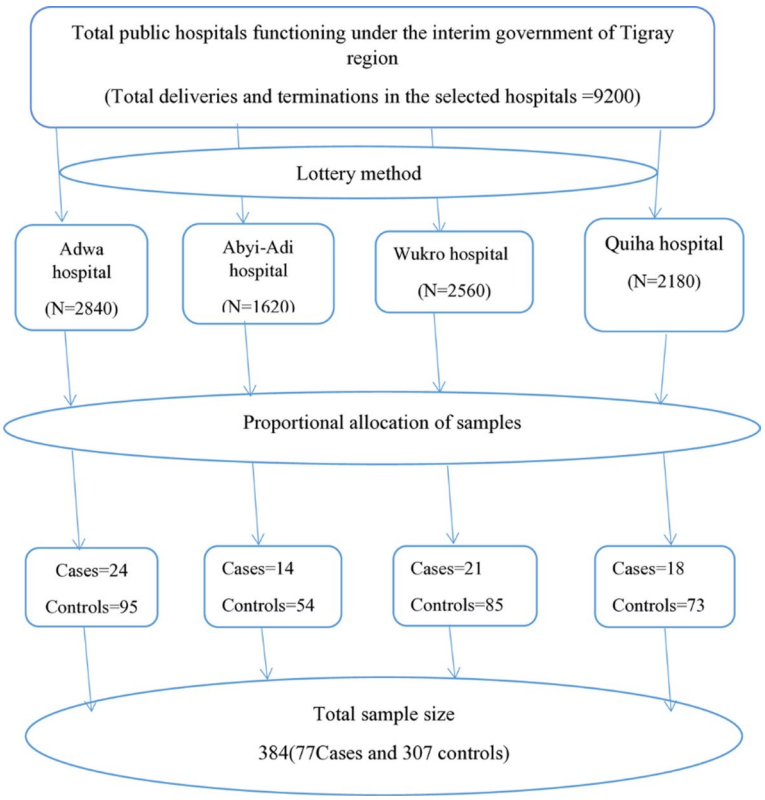

Fig. 1. Schematic presentation of sampling procedure to assess determinants of congenital anomalies in public hospitals of northern Ethiopia, 2024.

Control Mothers who delivered newborns without any detectable congenital anomalies, as confirmed by the physician through routine clinical examination at birth. Controls were selected from the same hospital and within the same time period as cases to ensure they arose from the same source population.

Food consumption score (FCS): It is derived from the frequency with which a household consumes different food groups over the seven days prior to the survey. Based on the calculated score, households are classified using standard thresholds: 0–21 = Poor, 21.5–35 = Borderline, and > 35 = Acceptable[22].

Medical illness during pregnancy Any self-reported or clinically diagnosed chronic or acute medical condition occurring during the current pregnancy.

Nutritional counseling Whether the mother received any advice or education on dietary practices during pregnancy from a health professional during an antenatal care visit.

Alcohol consumption Any self-reported consumption of alcoholic beverages during the current pregnancy.

Data collection tool and procedure

The questionnaire used was developed from different literatures conducted in Ethiopian and other African countries. Data was collected through interviewer-administered, pretested, and structured questionnaires. Additionally, chart reviews were conducted for certain maternal (maternal age, gestational age, mode of delivery, and medical illness during pregnancy) and newborn (sex of the newborn, type of congenital anomaly and birth weight) variables. Dietary intake during pregnancy was assessed using a FCS chart, adapted from the World Food Programme. The study employed three supervisors and four data collectors, all of whom held Bachelor of Science (BSC) degrees in midwifery, to carry out data collection in the study areas.

Data quality control

Two weeks before the actual data collection, a pretest with 20 participants (5% of the total sample size) was done at Suhul Hospital. That helped us to make minor adjustments to the questionnaire. To ensure linguistic accuracy and conceptual equivalence, the questionnaires were initially prepared in English, translated into Tigrigna by language experts, and then back-translated into English to verify consistency with the original version. Data collectors and supervisors attended a full day training session that explained to them how to conduct interviews, what the study's goals were, and what each part of the questionnaire was for. The principal investigator reviewed each questionnaire both during and after data collection to ensure completeness and maintain data quality.

Data management and analysis

The filled questionnaires were checked for completeness and entered into EpiData manager version 4.4.2.1 and analyzed using SPSS version 29 statistical package. We used binary logistic regression with a 95% confidence interval (CI) to look at how the outcome and explanatory variables were related. Initially, bivariable logistic regression was performed, and variables with a P-value ≤ 0.25 were included in the multivariable analysis to assess their independent effects. Multicollinearity was assessed by the variance inflation factor (VIF), while the Hosmer-Lemeshow test was used to assess the model's goodness-of-test. Variables with a P-value < 0.05 were considered statistically significant in determining the association between the dependent and independent variables. Finally, texts, frequency tables, and mean were used to report the results.

Results

Socio-demographic characteristics

The study included 77 cases and 307 controls, yielding a response rate of 100%. The mean age of the mothers was 27.91 ± 5.11years among the cases and 28.29 ± 5.30 years among the controls. Among the study participants, 48(62.3%) of the cases and 268(87.3%) of the controls were urban residents. The majority of the cases 72(93.5%) and controls 366(95.3%) were in marital relationship (Table 1).

Maternal obstetric, medical and newborn characteristics

Among the study participants, 69(89.6%) of the cases and 299(97.4%) of the controls had attended antenatal care follow up. Folic acid supplementation was reported in 50(64.9%) of cases and 283(92.2%) of controls. Only 3(3.9%) of the cases and 2(0.7%) of the controls reported a previous history of congenital anomalies. Of the study participants, 21(27.3%) of the cases and 30(9.8%) of the controls had a medical illness during the index pregnancy (Table 2).

Maternal life style, behavioral, environmental and nutritional characteristics

In the study participants, 7(9.1%) of the cases and 63(20.5) of the controls had an acceptable food consumption score. Of the study participants, 15(19.5%) of the cases and 124(40.4) of the controls received counselling on nutrition during pregnancy. Compared to before pregnancy, 16(20.8%) of the cases and 126(41.0%) of the controls consumed additional food during the index pregnancy. Only 28(36.4%) of the cases and 49(16.0%) of the controls reported alcohol consumption during the index pregnancy (Table 3).

Types and frequencies of congenital anomalies among newborns in public hospitals of Northern Ethiopia

Among the 77 cases, 23(29.9%) were diagnosed with anencephaly followed by spina bifida 15(19.5%) and encephalocele 11(14.2). Three newborns were diagnosed with multiple congenital anomalies. One case 1(1.3%)

Variable	Category	Cases ($n=77$)	Controls ($n=307$)	Total ($n=384$)
		Frequency (%)	Frequency (%)	Frequency (%)
Maternal age	< 35	66(85.7)	258(84.0)	324(84.4)
	≥ 35	11(14.3)	49(16.0)	60(15.6)
Religion	Orthodox	76(98.7)	296(96.4)	372(96.9)
	Muslim	1(1.3)	10(3.3)	11(2.9)
	Protestant	0(0)	1(0.3)	1(0.2)
Residence	Rural	29(37.7)	39(12.7)	68(17.7)
	Urban	48(62.3)	268(87.3)	316(82.3)
Maternal educational level	No formal education	7(9.1)	14(4.6)	21(5.5)
	Elementary school	32(41.6)	71(23.1)	103(26.8)
	High school	27(35.1)	117(38.1)	144(37.5)
	College and above	11(14.2)	105(34.2)	116(30.2)
Occupation	Government employee	6(7.8)	37(12.1)	43(11.2)
	Private employee	4(5.2)	17(5.5)	21(5.5)
	Merchant	4(5.2)	51((16.6)	55(14.3%)
	House wife	62(80.5)	193(62.9)	255(66.4)
	Student	1(1.3)	9(2.9)	10(2.6)
Marital status	In marital relationship	72(93.5)	294(95.8)	366(95.3)
	Not in marital relationship	5(6.5)	13(4.2)	18(4.7)
Sex of newborn	Male	49(63.6)	157(51.1)	206(53.6)
	Female	28(36.4)	150(48.9)	178(46.4)

Table 1. Socio-demographic characteristics of the study participants in public hospitals of Northern Ethiopia, 2024.

was diagnosed with cleft lip and cleft palate and another case 1(1.3%) was presented with Spina bifida and ventriculomegaly and the third case was diagnosed with ventriculomegaly, spina bifida and club foot (Table 4).

Determinants of congenital anomaly in public hospitals of Tigray region, Ethiopia

In the bivariable logistic regression analysis, factors including place of residence, newborn sex, antenatal care follow up, folic acid supplementation, history of abortion, birth weight, medical illness during the index pregnancy, food consumption score, nutritional counseling, taking additional food during pregnancy, alcohol consumption during pregnancy, exposure to pesticides during pregnancy, passive exposure to cigarette smoking during pregnancy and consumption of surface water during pregnancy were found to have a significant association with congenital anomaly at a p-value of ≤ 0.25. Therefore all these variables were included in the multiple logistic regression model. The multivariable analysis indicated that folic acid supplementation (AOR = 0.30, 95%CI: (0.12–0.69), birth weight (AOR = 4.17, 95% CI: 1.66–10.45), medical illness during pregnancy (AOR = 6.07, 95% CI: 2.58–14.29), food consumption score (AOR = 3.07, 95% CI: 1.11–8.42), nutritional counseling (AOR = 3.23, 95% CI: 1.50–7.04), intake of additional food during pregnancy (AOR = 2.34, 95% CI:1.10–4.98) and alcohol consumption during pregnancy (AOR = 2.80, 95% CI: 1.30–6.08) were significantly associated with congenital anomalies (Table 5).

Discussion

This study investigated the determinants of congenital anomalies in public hospitals of Tigray region. The findings revealed that folic acid supplementation, birth weight, medical illness during pregnancy, food consumption score, nutritional counseling, intake of additional food during pregnancy, and alcohol consumption during pregnancy were significantly associated with congenital anomalies.

In this study, women who received folic acid supplementation before or during pregnancy had 70% lower risk of giving birth to newborns with congenital anomalies compared to those who did not receive supplementation. This finding is consistent with studies conducted in Bishoftu General Hospital[6], Arsi zone public hospitals[23], south-western Ethiopia[24], and in Awi zone public hospitals[25] as well as with systematic reviews conducted in Ethiopia, and across Africa[2,5,11]. Scientific evidence indicated that folic acid is essential for DNA synthesis and cellular growth, and its requirement rises during pregnancy due to rapid fetal development. Supplementation fulfills this increased demand and has been shown to lower the risk of congenital anomalies[2,11].

In this study, newborns with birth weight of less than 2.5 kg had four times higher odds of having congenital anomaly compared to those weighing 2.5 kg or above. This is in line with the studies conducted in Bishoftu General Hospital[6], Felege-Hiwot Comprehensive Specialized Referral Hospital[7], eastern Ethiopia[8] and, with population-based registry study from the state of Qatar[26]. A possible explanation for this association is that the presence of major congenital anomalies often disrupts normal fetal growth and development leading to low birth weight.

This study found that mothers who experienced illnesses during pregnancy had six times higher odds of having newborns with congenital anomalies compared to those mothers without medical illness. The finding

Variable	Category	Cases ($n=77$)	Controls ($n=307$)	Total ($n=384$)
		Frequency (%)	Frequency (%)	Frequency (%)
Gestational age at birth	Preterm	37(48.1)	26(8.5)	63(16.4)
	Term	40(51.9)	279(90.9)	319(83.1)
	Post term	0(0)	2(0.7)	2(0.5)
Parity	< 3	57(74.0)	190(61.9)	247(64.3)
	≥ 3	20(26.0)	117(38.1)	137(35.7)
Antenatal care follow up	Yes	69(89.6)	299(97.4)	368(95.8)
	No	8(10.4)	8(2.6)	16(4.2)
Planned pregnancy	Yes	51(66.2)	236(76.9)	287(74.7)
	No	26(33.8)	71(23.1)	97(25.3)
Preconception care	Yes	2(2.6)	4(1.3)	6(1.6)
	No	75(97.4)	303(98.7)	378(98.4)
Folic acid supplementation	Yes	50(64.9)	283(92.2)	333(86.7)
	No	27(35.1)	24(7.8)	51(13.3)
Onset of labor	Spontaneous	57(74.0)	302(98.4)	359(93.5)
	Induced	20(26.0)	5(1.6)	25(6.5)
Mode of delivery	SVD	67(87.0)	223(72.6)	290(75.5)
	Instrumental	0(0)	2(0.7)	2(0.5)
	C/S	10(13.0)	82(26.7)	92(24.0)
Previous history of congenital anomaly	Yes	3(3.9)	2(0.7)	5(1.3)
	No	74(96.1)	305(99.3)	379(98.7)
Family history of congenital anomaly	Yes	6(7.8)	0(0)	6(1.6)
	No	71(92.2)	307(100)	378(98.4)
History of stillbirth	Yes	2(2.6)	15(4.9)	17(4.4)
	No	75(97.4)	292(95.1)	367(95.6)
History of abortion	Yes	17(22.1)	42(13.7)	59(15.4)
	No	60(77.9)	265(86.3)	325(84.6)
Birth weight	< 2.5	25(32.5)	16(5.2)	41(10.7)
	≥ 2.5	52(67.5)	291(94.8)	343(89.3)
Medical illness during pregnancy	Yes	21(27.3)	30(9.8)	51(13.3)
	No	56(72.7)	277(90.2)	333(86.7)
Anemia in the index pregnancy	Yes	10(13.0)	47(15.3)	57(14.8)
	No	67(87.0)	260(84.7)	327(85.2)

Table 2. Maternal obstetric, medical, and newborn characteristics of study participants in public hospitals of Northern Ethiopia, 2024.

is in line with studies conducted in Arsi zone public hospitals[23], umbrella review on congenital anomalies in low and middle-income countries[27], and systematic reviews conducted across Ethiopia and Africa[2,11]. Maternal illness during pregnancy can create an unfavorable intrauterine environment that disrupts the precise process of fetal organogenesis, resulting in congenital abnormalities. This environment is characterized by hypoxia, nutrient deficiencies, and metabolic disturbances. The finding is particularly important in Tigray region, where the collapse of the healthcare during the war limited maternal care, likely worsening illnesses and increasing their teratogenic impact on congenital anomalies[28].

According to this study, mothers with poor food consumption scores were three times more likely to have newborns with congenital anomalies than mothers with acceptable food consumption scores. This study finding is consistent with a study conducted in eastern Ethiopia that found a significant association between poor food consumption scores and neural tube defect[19].The people of the Tigray region resulted in widespread food insecurity as a result of the two-year civil war. Severe hunger has resulted from the conflict's disruption of agricultural production, destabilization of markets, and mass displacement[29]. As a result, pregnant women who are malnourished may have folate insufficiency in their bodies, which may cause their unborn babies to have neural tube defects.

This study found that mothers who did not receive dietary counseling during pregnancy had threefold higher odds of giving birth to newborns with congenital anomalies compared to those who received counseling. The study is consistent with the study conducted in Awi zone public hospitals[25], and western Kenya[30].Through the promotion of balanced diets, prevention of micronutrient deficiencies, avoidance of harmful habits, and support of healthy fetal growth and development, nutritional counselling lowers the risk of congenital conditions.

According to this study, pregnant women who inadequate food intake had a twofold higher chance of giving birth to newborns who had congenital defects than pregnant women who ate enough. This is in line with studies conducted in public referral hospitals in eastern Ethiopia[19] and China[31]. Reduced likelihood of neural tube

Variable	Category	Cases ($n=77$)	Controls ($n=307$)	Total ($n=384$)
		Frequency (%)	Frequency (%)	Frequency (%)
Food consumption score	Poor	48(62.8)	113(36.8)	161(42.0)
	Border line	22(28.6)	131(42.7)	153(39.8)
	Acceptable	7(9.1)	63(20.5)	70(18.2)
Nutritional counseling	Yes	15(19.5)	124(40.4)	102(26.6)
	No	62(80.5)	183(59.6)	282(73.4)
Additional food in pregnancy	Yes	16(20.8)	126(41.0)	142(37.0)
	No	61(79.2)	181(59.0)	242(63.0)
Alcohol consumption	Yes	28(36.4)	49(16.0)	77(20.1)
	No	49(63.6)	258(84.0)	307(79.9)
Exposure to radiation	Yes	3(3.9)	1(0.3)	4(1.0)
	No	74(96.1)	306(99.7)	380(99.0)
Exposure to pesticides	Yes	7(9.1)	8(2.6)	15(3.9)
	No	70(90.9)	299(97.4)	369(96.1)
Smoking during pregnancy	Yes	3(3.9)	4(1.3)	7(1.8)
	No	74(96.1)	303(98.9)	377(98.2)
Passive exposure to cigarette	Yes	7(9.1)	8(2.6)	15(3.9)
	No	70(90.9)	299(97.4)	369(96.1)
Surface water as a source of drinking	Yes	15(19.5)	12(3.9)	27(7.0)
	No	62(80.5)	295(96.1)	357(93.0)

Table 3. Maternal lifestyle, behavioral, environmental and nutritional characteristics of study participants in public hospitals of Northern Ethiopia, 2024.

Types of congenital anomalies ($n=77$)	Frequency (%)
Anencephaly	23(29.9)
Cleft lip	2(2.6)
Cleft lip + cleft palate	1(1.3)
Cleft palate	1(1.3)
Club foot	6(7.8)
Down's syndrome	2(2.6)
Encephalocele	11(14.2)
Gastroschisis	3(3.9)
Omphalocele	1(1.3)
Hydrocephalus	5(6.5)
Spina bifida	15(19.5)
Spina bifida + ventriculomegaly	1(1.3)
Ventriculomegaly	5(6.5)
Ventriculomegaly + Spina bifida + Club foot	1(1.3)
Total	77(100)

Table 4. Types and frequencies of congenital anomalies among newborns in public hospitals of Northern Ethiopia, 2024.

abnormalities and cleft anomalies was linked to maternal adherence to healthy food patterns, as evidenced by better diet quality ratings. This suggests that enhancing maternal nutrition could support food fortification programs, encourage the use of periconceptional multivitamins, and further reduce the incidence of serious birth abnormalities[19].

According to our study, mothers who consumed any amount of alcohol during pregnancy had three times more likely to have newborns with congenital anomalies than mothers who did not consume alcohol. This is supported by studies conducted in Arsi zone public hospitals[23], public hospitals in eastern Ethiopia[21], and systematic reviews conducted across Ethiopia and Africa[2,11]. Alcohol may affect fetal development by changing stem cell genomes through acetaldehyde, an endogenous and alcohol-derived cause of DNA damage that promotes cell degeneration. This probably reflects the fact that alcohol has complicated impacts on developmental processes[21].

Variable	Category	Cases($n=77$)	Controls($n=307$)	COR (95%CI)	AOR (95%CI)
		Frequency(%)	Frequency (%)		
Residence	Rural	29(37.7)	39(12.7)	1	1
	Urban	48(62.3)	268(62.3)	0.24(0.14–0.43)	0.50(0.23–1.07)
Sex of newborn	Male	49(63.6)	157(51.1)	1	1
	Female	28(36.4)	150(48.9)	0.60(0.36-1.00)	0.65(0.34–1.24)
Antenatal care follow up	Yes	69(89.6)	299(97.4)	1	1
	No	8(10.4)	8(2.6)	4.33(1.57-12.00)	1.06(0.25–4.42)
Folic acid supplementation	Yes	50(64.9)	283(92.2)	0.16(0.08–0.30)	**0.30(0.12–0.69)**
	No	27(35.1)	24(7.8)	1	1
History of abortion	Yes	17(22.1)	42(13.7)	1.78(0.95–3.35)	1.43(0.60–3.40)
	No	60(77.9)	265(86.3)	1	1
Birth weight	< 2.5	25(32.5)	16(5.2)	8.74(4.37–17.50)	**4.17(1.66–10.45)**
	≥ 2.5	52(67.5)	291(94.8)	1	1
Medical illness during pregnancy	Yes	21(27.3)	30(9.8)	3.46(1.85–6.48)	**6.07(2.58–14.29)**
	No	56(72.7)	277(90.2)	1	1
Food consumption score	Poor	48(62.8)	113(36.8)	3.82(1.63–8.95)	**3.07(1.11–8.42)**
	Borderline	22(28.6)	131(42.7)	1.51(0.61–3.73)	1.23(0.42–3.62)
	Acceptable	7(9.1)	63(20.5)	1	1
Nutritional counseling	Yes	15(19.5)	124(40.4)	1	1
	No	62(80.5)	183(59.6)	2.80(1.52–5.15)	**3.23(1.50–7.04)**
Additional food in pregnancy	Yes	16(20.8)	126(41.0)	1	1
	No	61(79.2)	181(59.0)	2.65(1.46–4.82)	**2.34(1.10–4.98)**
Alcohol consumption	Yes	28(36.4)	49(16.0)	3.00(1.73–5.25)	**2.80(1.30–6.08)**
	No	49(63.6)	258(84.0)	1	1
Exposure to pesticides	Yes	7(9.1)	8(2.6)	3.74(1.31–10.65)	1.55(0.30–8.10)
	No	70(90.9)	299(97.4)	1	1
Passive exposure to cigarette	Yes	7(9.1)	8(2.6)	3.74(1.31–10.65)	0.45(0.08–2.47)
	No	70(90.9)	299(97.4)	1	1
Surface water as a source of drinking	Yes	15(19.5)	12(3.9)	5.95(2.65–13.33)	1.90(0.60-6.00)
	No	62(80.5)	295(96.1)	1	1

Table 5. Bivariable and multivariable logistic regression analysis of determinants of congenital anomalies among newborns in public hospitals of Northern Ethiopia, 2024.

Conclusions and recommendations

This study identified several factors contributing to congenital anomalies in public hospitals of Tigray region. Low birth weight, maternal illness during pregnancy, poor food consumption, lack of nutritional counselling, inadequate additional food intake, and alcohol consumption were identified as risk factors, while folic acid supplementation prior to and during pregnancy functioned as a protective factor. Folic acid supplementation before or/and pregnancy, nutritional counselling, enhancing maternal nutrition during pregnancy is essential to reduce congenital anomalies. In addition to monitoring maternal and fetal health and promoting healthy eating habits while discouraging alcohol consumption, health facilities should guarantee early screening and management of maternal illnesses. Further research focused on longitudinal, community based, and interventional studies as well as health system related determinants of congenital anomalies is recommended.

Strengths and limitations

Strengths

The study provides critical and timely evidence from a post-war setting where the healthcare system was devastated and maternal health data were scarce. Its findings are directly relevant for guiding the recovery of health service in Tigray and similar conflict affected regions. The study identifies modifiable variables, including folic acid supplementation, nutritional counselling, and dietary intake, offering actionable knowledge to guide mother and child health interventions in fragile, resource-constrained, and conflict-affected environments. Although the health system was disrupted, the study's hospital setting ensured more accurate diagnosis and documentation. Physician diagnoses served as the basis for the study's outcome variable, guaranteeing accuracy and reliability in the identification of congenital anomalies.

Limitations

Since the study was conducted in a hospital, its generalizability might not apply to pregnant women in general, especially those who at home or private facilities. Data on certain exposures may be affected by recall bias and

social desirability bias. In addition, genetic factors were not assessed which could have significant effect on congenital anomalies.

Data availability

All relevant data supporting this study are with in manuscript.

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Author contributions

GG, FF, GM: conceptualization. GG, GGM, EAD: data curation. GG, BMN, GM: investigation.GG, FF, BMN: methodology **.** GG, EAD, BA: project administration. GG, GKA, GWG: resources. GG, GGM, GWG: software. GG, BMN, BA: supervision. GG, GGM, BA: validation.BMN, GKA: visualization. GG, FF, BMN: writing-original draft **.** GG, FF, BMN: writing-review and editing.

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Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

This study received ethical approval from the Institutional Review Board (IRB) of Aksum University College of Health Sciences (Ref. No: 035/2024) on February 29, 2024.All methods were performed in accordance with relevant guidelines and regulations, including the principles of the Declaration of Helsinki. Formal permission was secured from administrative authorities at all participating hospitals prior to data collection. To ensure confidentiality, all data were anonymized at the point of collection, with participant identifiers replaced by coded numbers. For illiterate participants, consent was obtained via thumbprint in the presence of an impartial witness. All participants, including guardians of newborns provided written informed consent after the studies goal, procedures, risks, and benefits were elucidated. Participation was voluntary, and respondents retained the right to withdraw at any stage without consequence.

Consent for publication

Not applicable.

Additional information

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