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Orapuh Journal

ORIGINAL ARTICLE

Journal of Oral & Public Health

Determinants of neonatal mortality in hospitals in the Tshopo province of the Democratic Republic of Congo

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ARTICLE INFO

Received: *18 July 2025*
Accepted: *22 August 2025*
Published: *30 September 2025*

Keywords:
Determinants, neonatal mortality, hospital environment, Tshopo province

Peer-Review: *Externally peer-reviewed*

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Ramazani-Tabora, J., Atuba, P. M., Ramazani-Bongolu, B., Botokomoy, O. M., Ngbolua, K. N., Mbungu, R. M., & Tshimungu, F. K. (2025). Determinants of neonatal mortality in hospitals in the Tshopo province of the Democratic Republic of Congo. *Orapuh Journal, 6*(9), e1290
https://dx.doi.org/10.4314/orapj.v6i9.90

ISSN: *2644-3740*

Published by Orapuh, Inc. (info@orapuh.org)

Editor-in-Chief: Prof. V. E. Adamu
Orapuh, Inc., UMTG PMB 405, Serrekunda, The Gambia, editor@orapuh.org.

ABSTRACT

Introduction

Neonatal mortality is a major global public health issue, with uneven distribution across regions. Its determinants remain poorly understood in Tshopo province.

Purpose

This study aimed to identify the determinants of neonatal mortality in hospitals in the Tshopo province of the Democratic Republic of Congo.

Methods

A case-control study was conducted in the maternity wards of selected hospitals. Based on records in the children's files, deaths occurring during the first 28 days were classified as cases, and survivors were considered controls. Data were collected using a structured questionnaire administered by trained interviewers. Statistical analysis was performed using Jamovi 2.6.44. Descriptive statistics, association tests, and binary logistic regression were employed to identify determinants at a 95% confidence level.

Results

Binary logistic regression revealed the following determinants: insufficient tetanus vaccination (ORa = 2.1, 95% CI [1.2–3.7], p = 0.007); presence of pregnancy pathologies (ORa = 4.4, 95% CI [2.7–7.1], p < 0.001), including high blood pressure (ORa = 9.4, 95% CI [3.7–23.8], p < 0.001), gonorrhea (ORa = 4.1, 95% CI [1.6–10.1], p = 0.003), and malaria (ORa = 2.4, 95% CI [1.4–4.3], p = 0.002). Other determinants included scarred uterus (ORa = 0.4, 95% CI [0.3–0.9], p = 0.019), prematurity (ORa = 3.2, 95% CI [1.1–9.4], p = 0.033), fetal distress (ORa = 6.6, 95% CI [3.5–12.47], p < 0.001), out-of-hospital delivery (ORa = 2.2, 95% CI [1.0–4.5], p = 0.037), male newborn (ORa = 1.6, 95% CI [1.0–2.4], p = 0.042), and low birth weight (ORa = 3.8, 95% CI [2.0–7.2], p < 0.001).

Conclusion

This study underscores the need for concerted efforts to improve maternal and neonatal health in Tshopo province. It demonstrates that effective pre-, intra-, and postnatal monitoring can reduce neonatal mortality.

INTRODUCTION

Neonatal mortality, defined as all deaths occurring from birth to the twenty-eighth day (Sartorius et al., 2024), is a major public health problem worldwide, with up to 7,000 cases occurring daily (Mangold et al., 2021), particularly during the first week after birth (Gesso et al., 2025). Its prevalence remains high in many regions, especially in developing countries, including most African nations and sub-Saharan Africa in particular (Ahmed et al., 2023; GBD 2019 Under-5 Mortality Collaborators, 2021; Moges et al., 2024).

Being one of the best indicators of health system performance and a key component of infant mortality, neonatal mortality is often assessed in two stages: early neonatal mortality and late neonatal mortality (Irana et al., 2023). Furthermore, several factors influence neonatal mortality, including sociodemographic, cultural, economic, health-related factors, and specific characteristics of the newborn (Correa-de-Araujo & Yoon, 2021; Mackay et al., 2025; Tekeba et al., 2024).

In the Democratic Republic of Congo, particularly in the Tshopo province, neonatal mortality remains alarmingly high. In a 2022 study conducted in this province, the neonatal mortality rate in Kisangani, the provincial capital, was estimated at 333 deaths per 1,000 live births (Ramazani Tabora et al., 2022). This figure underscores the urgency of conducting in-depth research to identify the specific determinants of neonatal mortality in this region.

Several reasons justify this study. First, neonatal mortality has profound and lasting consequences on the well-being of families and communities, affecting parents and the social and economic dynamics of the region. Second, although previous studies have explored neonatal mortality in other contexts, little research has specifically focused on Tshopo province. Finally, the findings of this study will provide evidence to inform targeted prevention strategies aimed at reducing neonatal mortality and improving maternal and child health in Tshopo province.

Purpose

This study was initiated to identify the determinants of neonatal mortality in hospitals in Tshopo province, Democratic Republic of Congo.

METHODS

Design

A case-control epidemiological study was conducted to identify the determinants of neonatal mortality in Tshopo province.

Study Population

The study focused on mother-newborn pairs who received care at health facilities in Tshopo province between 2022 and 2023. Inclusion criteria were: mothers who gave birth in health facilities in Tshopo province between January 2022 and December 2023; children aged 0–28 days at the time of death for the case group; living children of the same age for the control group; and voluntary consent to participate.

Exclusion criteria included: mothers not residing in Tshopo province, children from multiple pregnancies (twins, triplets, etc.), and mothers with a language barrier.

Sampling

A total of 230 cases (neonatal deaths) and 460 controls (living children) were recruited. Stratified random sampling was used to ensure representation from both rural and urban areas of the province.

Recruitment of Participants

Participants were identified from health facility records. In the maternity wards of selected facilities, deaths occurring within the first 28 days were classified as cases, and surviving children of the same age were included as controls. Additional information not available in medical files, mainly sociodemographic data, was collected by following up with mothers in their homes when necessary.

Data Collection

Data were collected using a structured questionnaire administered by trained interviewers. The questionnaire covered:

- Sociodemographic characteristics (age, education, marital status, place of residence)
- Medical history (maternal health during pregnancy, pathologies, vaccinations, prenatal consultations)
- Delivery conditions (type of delivery, place of birth, complications)

- Newborn characteristics (sex, birth weight, APGAR scores at 3 and 5 minutes) Pregnancy outcome was the dependent variable.

Bias Control

Several strategies were implemented to control potential biases:

- **Selection bias:** minimized through stratified random sampling and matching controls with cases by age and place of residence.
- **Recall bias:** mitigated by using a standardized questionnaire administered by trained interviewers.
- **Information bias:** data were validated by study managers, and medical records were used to corroborate health status information.
- **Non-response bias:** participants were offered appropriate incentives, and follow-ups were conducted for non-respondents.
- **Confounding:** logistic regression analyses adjusted for confounding factors to accurately assess associations between determinants and neonatal mortality.

Data Analysis

Data were analysed using Jamovi version 2.6.44. Analysis proceeded in three stages:

1. Descriptive statistics characterized the case and control groups.
2. Chi-square or Fisher's exact tests assessed differences between groups.
3. Binary logistic regression identified determinants of neonatal mortality. Odds ratios (OR) and 95% confidence intervals (CI) were calculated.

Ethical Considerations

The study adhered to ethical research principles. Informed consent was obtained from all participants. Ethical approval was granted by the Ethics Committee of the Higher Institute of Medical Techniques of Kinshasa (No. 0024/CBE/ISTM/KIN/RDC/PMBBL/2023, 29 November 2023).

RESULTS

Participant Profile

A total of 690 mother-newborn pairs were included in the study, comprising 230 cases (neonatal deaths) and 460 controls (living newborns). Sociodemographic characteristics of the participants are presented in **Table 1.**

Table 1:
Sociodemographic Characteristics of Participants

Sociodemographic characteristics	Status of the child				p-value
	Deceased (case)		Living (control)		
	Number n = 230	(%)	Number n = 460	(%)	
Mother's age					
< 20	39	(17)	89	(19.3)	0.405
20 - 34	169	(73.5)	339	(73.7)	
35 and over	22	(9.6)	32	(7)	
Educational level					
Weak	211	(91.7)	427	(92.8)	0.61
Pupil	19	(8.3)	33	(7.2)	
Place of residence					
Rural	103	(44.8)	201	(43.7)	0.786
Urban	127	(55.2)	259	(56.3)	
Marital status					
Bride)	91	(39.6)	172	(37.4)	0.579
Free union	139	(60.4)	288	(62.6)	

Note: There were no statistically significant differences in sociodemographic characteristics between cases and controls (p > 0.05).

The majority of mothers were aged 20–34 years (73.5% of cases and 73.7% of controls), and most had low educational attainment (91.7% of cases and 92.8% of controls). Slightly more than half of the participants resided in urban areas (55.2% of cases and 56.3% of controls), and the majority were in a free union (60.4% of cases and 62.6% of controls). There were no statistically significant differences between cases and controls with respect to mothers' age, educational level, place of residence, or marital status ($p > 0.05$), indicating comparable demographic profiles across the two groups.

Obstetric Characteristics

Table 2 summarises the obstetric characteristics of the study population. Significant differences were observed between cases and controls for several variables. Mothers of deceased neonates were less likely to have attended prenatal consultations (86.5% vs. 97.6%, $p < 0.001$) and were more likely to have fewer than three prenatal visits (60.9% vs. 53.5%, $p = 0.065$). Tetanus vaccination within the last five years was less common among cases (84.8% vs. 95.2%, $p < 0.001$), and vaccination coverage ≤2 times was higher among cases (73.9% vs. 56.3%, $p < 0.001$). Maternal illness

during pregnancy was also more frequent in the case group (61.3% vs. 16.7%, $p < 0.001$). No significant differences were observed regarding special diet during pregnancy or interbirth interval ($p > 0.05$). Other factors significantly associated with neonatal death included type of delivery, scarred uterus, prematurity, caesarean section, fetal presentation, feto-pelvic disproportion, fetal distress, and place of birth ($p < 0.05$).

Table 2:
Obstetric Characteristics of Participants

Obstetric characteristics	Status of the child				p-value
	Deceased (case)		Living (control)		
	Effective n = 230	(%)	Number n = 460	(%)	
Special diet during pregnancy					
No	203	(88.3)	423	(92.0)	0.115
Yes	27	(11.7)	37	(8.0)	
Prenatal consultation					
No	31	(13.5)	11	(2.4)	< 0.001
Yes	199	(86.5)	449	(97.6)	
Number of CPNs performed					
< 3	140	(60.9)	246	(53.5)	0.065
4 and more	90	(39.1)	214	(46.5)	
Tetanus vaccination in the last 5 years					
No	35	(15.2)	22	(4.8)	< 0.001
Yes	195	(84.8)	438	(95.2)	
Number of vaccination times					
≤ 2	170	(73.9)	259	(56.3)	< 0.001
3 and more	60	(26.1)	201	(43.7)	
Illness during pregnancy					
No	89	(38.7)	383	(83.3)	< 0.001
Yes	141	(61.3)	77	(16.7)	
Parity					
Multiparous	154	(67.0)	335	(72.8)	0.11
Primiparous	76	(33.0)	125	(27.2)	
Interbirth interval ≤ 2 years					
≤ 2 years	198	(86.1)	386	(83.9)	0.455
> 2 years	32	(13.9)	74	(16.1)	
Type of delivery					
Low way	192	(83.5)	432	(93.9)	< 0.001
High road	38	(16.5)	28	(6.1)	
Scarred uterus					
No	184	(80.0)	398	(86.5)	0.026
Yes	46	(20.0)	62	(13.5)	
Prematurity					
No	203	(88.3)	452	(98.3)	< 0.001
Yes	27	(11.7)	8	(1.7)	
Caesarean section					
No	218	(94.8)	452	(98.3)	0.010
Yes	12	(5.2)	8	(1.7)	
Seat presentation					
No	208	(90.4)	449	(97.6)	< 0.001
Yes	22	(9.6)	11	(2.4)	
Fetopelvic disproportion					
No	217	(94.3)	451	(98.0)	0.009
Yes	13	(5.7)	9	(2.0)	
Fetal distress					
No	141	(61.3)	423	(92.0)	< 0.001
Yes	89	(38.7)	37	(8.0)	
Place of birth					
At home	33	(14.3)	29	(6.3)	< 0.001
At the maternity ward	197	(85.7)	431	(93.7)	

Note: Significant differences were observed for prenatal consultation, tetanus vaccination, illness during pregnancy, type of delivery, scarred uterus, prematurity, caesarean section, fetal presentation, feto-pelvic disproportion, fetal distress, and place of delivery ($p < 0.05$). No significant differences were observed for special diet, number of prenatal consultations, and interbirth interval.

Pregnancy Pathologies

As shown in **Table 3**, certain maternal pathologies were significantly associated with neonatal mortality. Hypertension (20% of cases vs. 2.4% of controls, $p < 0.001$), pre-eclampsia (4.3% vs. 0.9%, $p = 0.002$), gonorrhea (11.3% vs. 2.4%, $p < 0.001$), and malaria (50.9% vs. 17.4%, $p < 0.001$) were more prevalent among mothers of deceased neonates. Other conditions, such as gestational diabetes and genital infections, did not show statistically significant associations ($p > 0.05$).

Table 3:
Pathologies During Pregnancy and Neonatal Mortality

Pathologies during pregnancy	Status of the child				p-value
	Deceased (case)		Living (witness)		
	Number n = 230	(%)	Number n = 460	(%)	
Hypertension arterial	46	(20)	11	(2.4)	<0.001
Diabetes pregnant	4	(1.7)	2	(0.4)	0.082
Preeclampsia	10	(4.3)	4	(0.9)	0.002
Infection genital	8	(3.5)	7	(1.5)	0.097
Gonorrhea	26	(11.3)	11	(2.4)	<0.001
Malaria	117	(50.9)	80	(17.4)	<0.001

Note: Neonatal deaths were significantly associated with hypertension, preeclampsia, gonorrhea, and malaria ($p < 0.05$).

Newborn Characteristics

Newborn characteristics are presented in **Table 4**. Male neonates were more likely to die than females (54.3% vs. 41.7%, $p = 0.002$). Low APGAR scores at three minutes (<7) were observed more frequently among cases (62.6% vs. 53.0%, $p = 0.017$), and similar trends were seen at five minutes (36.1% vs. 44.1%, $p = 0.043$). Low birth weight was significantly more common among deceased neonates (24.3% vs. 8.5%, $p < 0.001$).

Table 4:
Newborn Characteristics and Neonatal Mortality

Characteristics of the newborn	Status of the child				p-value
	Deceased (case)		Living (Witness)		
	Number n = 230	(%)	Number n = 460	(%)	
Gender of the child					
Female	105	(45.7)	268	(58.3)	0.002
Male	125	(54.3)	192	(41.7)	
APGAR score at 3 minutes					
Less than 7	144	(62.6)	244	(53.0)	0.017
Greater than 7	86	(37.4)	216	(47.0)	
APGAR score at 5 minutes					
Less than 7	83	(36.1)	203	(44.1)	0.043
Greater than 7	147	(63.9)	257	(55.9)	
Low birth weight					
No	174	(75.7)	421	(91.5)	<0.001
Yes	56	(24.3)	39	(8.5)	

Note: Neonatal mortality differed significantly by sex, APGAR scores at 3 and 5 minutes, and low birth weight (p < 0.05).

Determinants of Neonatal Mortality

Binary logistic regression analysis (**Table 5**) identified several determinants of neonatal mortality in the hospital environment of Tshopo province. Significant risk factors included: vaccination ≤2 times (ORa = 2.15, 95% CI [1.23–3.74], p = 0.007), presence of pregnancy-related illness (ORa = 4.39, 95% CI [2.72–7.10], p < 0.001), vaginal delivery (ORa = 2.84, 95% CI [1.21–6.65], p = 0.017), scarred uterus (ORa = 0.44, 95% CI [0.22–0.88], p = 0.019), pregnancy-induced hypertension (ORa = 9.43, 95% CI [3.73–23.82], p < 0.001), gonorrhea (ORa = 4.06, 95% CI [1.64–10.08], p = 0.003), malaria (ORa = 2.44, 95% CI [1.39–4.29], p = 0.002), prematurity (ORa = 3.20, 95% CI [1.10–9.37], p = 0.033), fetal distress (ORa = 6.62, 95% CI [3.54–12.39], p < 0.001), childbirth outside the maternity ward (ORa = 2.18, 95% CI [1.05–4.52], p = 0.037), male gender (ORa = 1.58, 95% CI [1.02–2.45], p = 0.042), and low birth weight (ORa = 3.81, 95% CI [2.01–7.20], p < 0.001).

Table 5:
Binary Logistic Regression Analysis of Determinants of Neonatal Mortality

Factors	ORa	95% CI		p-value
		Lower	Superior	
Ordinate at the origin	***0.0298***	***0.0141***	***0.0630***	***<.001***
No ANC	2.7707	0.9420	8.1490	0.064
No tetanus vaccination	1.4903	0.6194	3.5857	0.373
Vaccination ≤ 2 times	*2.1472*	*1.2335*	*3.7375*	*0.007***
Pregnancy-related illness	*4.3913*	*2.7156*	*7.1010*	*<.001***
Vaginal delivery	*2.8360*	*1.2095*	*6.6497*	*0.017**
Scarred uterus	*0.4415*	*0.2227*	*0.8753*	*0.019**
Pregnancy-induced hypertension	*9.4294*	*3.7320*	*23.8247*	*<.001****
Preeclampsia	3.1268	0.7048	13.8725	0.134
Gonorrhea	*4.0622*	*1.6369*	*10.0813*	*0.003***
Malaria	*2.4411*	*1.3895*	*4.2888*	*0.002***
Prematurity	*3.2042*	*1.0956*	*9.3708*	*0.033**
Bad presentation	1.7829	0.6556	4.8485	0.257
Fetal-pelvic disproportion	1.1018	0.3026	4.0116	0.883
Fetal distress	*6.6221*	*3.5395*	*12.3891*	*<.001****
Childbirth outside the maternity ward	*2.1779*	*1.0491*	*4.5212*	*0.037**
Male gender	*1.5782*	*1.0176*	*2.4474*	*0.042**
APGAR ≤ 7 at 3 min	1.0130	0.6127	1.6746	0.960
APGAR ≤ 7 after 5 min	1.2153	0.7584	1.9476	0.418
Low birth weight	*3.8085*	*2.0136*	*7.2032*	*<.001***

Note. The estimate represents the log odds of "Child Status = Deceased" vs. "Child Status = Alive"
**** Significant difference at the 0.05 threshold***
***** Significant difference at the 0.01 level***
****** Significant difference at the 0.001 level***

*Note: The estimate represents the log odds of "Child Status = Deceased" vs. "Child Status = Alive." *Significance levels: *p < 0.05; **p < 0.01; **p < 0.001.*

These findings indicate that both maternal health factors (such as hypertension, malaria, gonorrhea, and prematurity) and neonatal characteristics (male sex, low birth weight, and fetal distress) significantly increase the risk of neonatal mortality. Preventive interventions targeting these determinants are critical for reducing neonatal deaths in Tshopo province.

DISCUSSION

Determinants of Neonatal Mortality

The results of this study indicate that neonatal mortality was influenced by maternal health during pregnancy, characteristics of delivery (process and mode), and neonatal characteristics.

Maternal Factors

Our findings show that children born to mothers who were not fully vaccinated against tetanus had at least twice the risk of dying during the neonatal period (ORa = 2.1 [1.2–3.7]; p = 0.007). This outcome likely reflects the lack of protective benefits from incomplete vaccination during pregnancy, as 73.9% of deceased newborns had mothers who received fewer than three of the five recommended doses for women of childbearing age. Vaccination during pregnancy can reduce maternal mortality and neonatal death by preventing complications and enhancing neonatal resilience (Carcelen et al., 2021). The tetanus vaccine, along with other recommended vaccines, is strongly advised during pregnancy and the immediate postpartum period (Guzman-Holst et al., 2023; Murphy et al., 2008; Miraglia Del Giudice et al., 2025).

In addition, the presence of pregnancy-related pathologies (ORa = 4.4 [2.7–7.1]; p < 0.001), including hypertension (ORa = 9.4 [3.7–23.8]; p < 0.001), gonorrhea (ORa = 4.1 [1.6–10.1]; p = 0.003), and malaria (ORa = 2.4 [1.4–4.3]; p = 0.002), increased the risk of neonatal death within the first 28 days. Previous studies confirm that maternal hypertension is associated with higher risks of both maternal and feto-neonatal mortality (Farahi et al., 2024; Cífková, 2023; Kipnis et al., 2022), with up to 10% of cases resulting in neonatal death (Bajpai et al., 2023). Similarly, sexually transmitted infections and other maternal infections negatively affect pregnancy outcomes and neonatal survival (Ravindran et al., 2021; Olaleye et al., 2020; Lara-Escandell et al., 2024; Gamberini et al., 2023; Mussa et al., 2023). Malaria during pregnancy has also been associated with low birth weight and increased neonatal mortality (Chua et al., 2021). Furthermore, severe maternal morbidity is closely linked with adverse neonatal outcomes (Ukah et al., 2024). These findings underscore the importance of effective management of maternal conditions to prevent neonatal complications.

Neonatal Factors

Newborns experiencing fetal distress (ORa = 6.6 [3.5–12.47]; p < 0.001) or born outside a maternity ward (ORa = 2.2 [1.0–4.5]; p = 0.037) were at greater risk of neonatal death. Fetal distress indicates intrauterine hypoxia, which poses significant risks to both the fetus and mother (Deng et al., 2023). Untreated cardiac anomalies such as supraventricular tachycardia can also result in fetal or neonatal death (Bhatia et al., 2020). Birth outside a hospital increases perinatal mortality due to limited access to skilled care and emergency interventions (Lang et al., 2021; Grünebaum et al., 2020). Moreover, lack of advanced medical equipment, rapid diagnostics, and comprehensive postpartum care contributes to adverse outcomes (Bellini et al., 2025).

Premature newborns (ORa = 3.2 [1.1–9.4]; p = 0.033), low birth weight infants (ORa = 3.8 [2.0–7.2]; p < 0.001), and male newborns (ORa = 1.6 [1.0–2.4]; p = 0.042) also faced higher mortality risks. Prematurity is associated with organ immaturity, increasing vulnerability to complications (Dai et al., 2024; Atuba et al., 2023; Kebede & Kekulawala, 2021). Similarly, low birth weight significantly increases the risk of early and late neonatal death (Gesso et al., 2025). Male neonates consistently show slightly higher mortality rates compared with females, a trend observed in this study and others.

Reflection on Confounding Factors and Causality

The study highlights the influence of confounding factors, such as socioeconomic status and access to healthcare, which may affect both maternal vaccination and neonatal mortality. Establishing clear causal relationships requires further research that isolates individual risk factors. While maternal vaccination and management of pregnancy complications are critical, addressing social determinants of health is equally essential to reduce neonatal mortality.

Limitations and Strengths

Limitations of this study include reliance on secondary data for certain neonatal variables and potential recall bias from mothers. Strengths include rigorous data collection, multivariate analysis using binary logistic regression, and clear presentation of results, which support generalization across Tshopo Province.

CONCLUSION

This study identified key determinants of neonatal mortality in Tshopo Province, Democratic Republic of Congo. Maternal vaccination, pregnancy-related complications, preterm birth, low birth weight, male gender, fetal distress, and out-of-hospital delivery were significant predictors of neonatal death.

These findings underscore the need to improve maternal and neonatal healthcare, particularly in rural areas. Targeted interventions may include increasing vaccination coverage, enhancing access to antenatal care, training health personnel in maternal pathology management, and implementing mobile health services. Awareness campaigns, psychosocial support, financial assistance for low-income families, and longitudinal surveillance systems are also recommended to reduce neonatal mortality and inform public health policy.

Acknowledgments: The authors thank the political and health authorities who facilitated the study and the mothers who participated by providing information.

Ethical Approval: The research protocol was approved by the Ethics Committee of the Higher Institute of Medical Techniques of Kinshasa (No. 0024/CBE/ISTM/KIN/RDC/PMBBL/2023, 29 November 2023).

Conflicts of Interest: None declared.

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REFERENCES

Ahmed, A. T., Farah, A. E., Ali, H. N., & Ibrahim, M. O. (2023). Determinants of early neonatal mortality (hospital based retrospective cohort study in Somali region of Ethiopia). *Scientific Reports, 13*(1), 1114. https://doi.org/10.1038/s41598-023-28357-x

Atuba, P. M., Pala, L. L., & Andjelani, A. N. (2023). Prevalence and risk factors in perinatal morbidity and mortality in the hospital environment of Kinshasa, DRC. In V. P. Veeramani (Ed.), *Advanced concepts in medicine and medical research* (Vol. 5, pp. 207–219). BP International (a part of SCIENCEDOMAIN International). https://doi.org/10.9734/bpi/acmmr/v5/1840G

Bajpai, D., Popa, C., Verma, P., Dumanski, S., & Shah, S. (2023). Evaluation and management of hypertensive disorders of pregnancy. *Kidney360, 4*(10), 1512–1525. https://doi.org/10.34067/KID.0000000000000228

Bellini, T., Vinci, F., Polleri, G., Pezzotta, F., Grasselli, L., Piccotti, E., Ramenghi, L. A., Moscatelli, A., & Striano, P. (2025). Adverse outcomes in neonates following planned home births: A case report series and a narrative literature review. *Journal of Clinical Medicine, 14*(4), 1181. https://doi.org/10.3390/jcm14041181

Bhatia, S. S., Burgess, W. H., & Skinner, J. R. (2020). Fetal tachycardia in the delivery room: Fetal distress, supraventricular tachycardia, or both? *AJP Reports, 10*(4), e380–e385. https://doi.org/10.1055/s-0040-1718900

Carcelen, A. C., Vilajeliu, A., Malik, F., Gilman, R. H., & Omer, S. (2021). Perceptions and attitudes towards vaccination during pregnancy in a peri-urban area of Lima, Peru. *Vaccine, 39*(Suppl 2), B27–B33. https://doi.org/10.1016/j.vaccine.2020.10.031

Chua, C. L. L., Hasang, W., Rogerson, S. J., & Teo, A. (2021). Poor birth outcomes in malaria in pregnancy: Recent insights into mechanisms and prevention approaches. *Frontiers in Immunology, 12*, 621382. https://doi.org/10.3389/fimmu.2021.621382

Cífková, R. (2023). Hypertension in pregnancy: A diagnostic and therapeutic overview. *High Blood Pressure & Cardiovascular Prevention, 30*(4), 289–303. https://doi.org/10.1007/s40292-023-00582-5

Correa-de-Araujo, R., & Yoon, S. S. (2021). Clinical outcomes in high-risk pregnancies due to advanced maternal age. *Journal of Women's Health, 30*(2). https://doi.org/10.1089/jwh.2020.8860

Dai, Z., Zhong, X., Chen, Q., Chen, Y., Pan, S., Ye, H., & Tang, X. (2024). Identification of neonatal factors predicting pre-discharge mortality in extremely preterm or extremely low birth weight infants: A historical cohort study. *Children, 11*(12), 1453. https://doi.org/10.3390/children11121453

Deng, Y., Zhang, Y., Zhou, Z., Zhang, X., Jiao, P., & Zhao, Z. (2023). A lightweight fetal distress-assisted diagnosis model based on a cross-channel interactive attention mechanism. *Frontiers in Physiology, 14*, 1090937. https://doi.org/10.3389/fphys.2023.1090937

Farahi, N., Oluyadi, F., & Dotson, A. B. (2024). Hypertensive disorders of pregnancy. *American Family Physician, 109*(3), 251–260.

Gamberini, C., Juliana, N. C. A., de Brouwer, L., Vogelsang, D., Al-Nasiry, S., Morré, S. A., & Ambrosino, E. (2023). The association between adverse pregnancy outcomes and non-viral genital pathogens among women living in sub-Saharan Africa: A systematic review. *Frontiers in Reproductive Health, 5*, 1107931. https://doi.org/10.3389/frph.2023.1107931

GBD 2019 Under-5 Mortality Collaborators. (2021). Global, regional, and national progress towards Sustainable Development Goal 3.2 for neonatal and child health: All-cause and cause-specific mortality findings from the Global Burden of Disease Study

2019. *Lancet, 398*(10303), 870–905. https://doi.org/10.1016/S0140-6736(21)01207-1

Gesso, A. S., Gonfa, G. K., & Awol, M. A. (2025). Survival status and predictors of early neonatal mortality among neonates admitted to neonatal intensive care units in Addis Ababa public hospitals, Ethiopia: A retrospective cohort study. *PLoS One, 20*(5), e0323600. https://doi.org/10.1371/journal.pone.0323600

Grünebaum, A., McCullough, L. B., Orosz, B., & Chervenak, F. A. (2020). Neonatal mortality in the United States is related to location of birth (hospital versus home) rather than the type of birth attendant. *American Journal of Obstetrics and Gynecology, 223*(2), 254.e1–254.e8. https://doi.org/10.1016/j.ajog.2020.01.045

Guzman-Holst, A., Petrozzi, V., Velez, C., Gupta, V., Ochoa, T. J., & Juliao, P. (2023). Knowledge, attitudes, and practices concerning maternal immunization among pregnant/postpartum women and health care professionals in Peru. *Infectious Diseases and Therapy, 12*(4), 1151–1173. https://doi.org/10.1007/s40121-023-00788-z

Irana, T., Mekebo, G. G., Diriba, G., Sisay, A. L., Woldeyohannes, B., & Yohannes, Z. (2023). Determinants of infant mortality in Oromia region, Ethiopia. *Annals of Medicine and Surgery, 85*(6), 2791–2796. https://doi.org/10.1097/MS9.0000000000000842

Kebede, E., & Kekulawala, M. (2021). Risk factors for stillbirth and early neonatal death: A case-control study in tertiary hospitals in Addis Ababa, Ethiopia. *BMC Pregnancy and Childbirth, 21*(1), 641. https://doi.org/10.1186/s12884-021-04025-8

Kipnis, C. M., Daly, P. L., Goodwin, E. T., & Smith, D. K. (2022). Hypertensive conditions: Hypertensive disorders in pregnancy. *FP Essentials, 522*, 25–33.

Lang, G., Farnell, E. A., & Quinlan, J. D. (2021). Out-of-hospital birth. *American Family Physician, 103*(11), 672–679.

Lara-Escandell, M., Gamberini, C., Juliana, N. C. A., Al-Nasiry, S., Morré, S. A., & Ambrosino, E. (2024). The association between non-viral sexually transmitted infections and pregnancy outcomes in Latin America and the Caribbean: A systematic review. *Heliyon, 10*(1), e23338. https://doi.org/10.1016/j.heliyon.2023.e23338

Mackay, A., Ishoso, D., Mafuta, E., Eilevstjønn, J., Gomez, P., Carlo, W., Bauserman, M., Bose, C., & Patterson, J. K. (2025). Establishment of a neonatal resuscitation registry in the Democratic Republic of the Congo: An open cohort study. *PLoS One, 20*(5), e0324332. https://doi.org/10.1371/journal.pone.0324332

Mangold, C., Zoretic, S., Thallapureddy, K., Moreira, A., Chorath, K., & Moreira, A. (2021). Machine learning models for predicting neonatal mortality: A systematic review. *Neonatology, 118*(4), 394–405. https://doi.org/10.1159/000516891

Miraglia Del Giudice, G., Angelillo, S., Sansone, V., Della Polla, G., Angelillo, I. F., & Collaborative Working Group. (2025). Knowledge, willingness, and hesitancy toward recommended vaccinations among pregnant and postpartum women: A cross-sectional survey in Italy. *Human Vaccines & Immunotherapeutics, 21*(1), 2485653. https://doi.org/10.1080/21645515.2025.2485653

Murphy, T. V., Slade, B. A., Broder, K. R., Kretsinger, K., Tiwari, T., Joyce, P. M., Iskander, J. K., Brown, K., Moran, J. S., & Advisory Committee on Immunization Practices (ACIP) Centers for Disease Control and Prevention (CDC). (2008). Prevention of pertussis, tetanus, and diphtheria among pregnant and postpartum women and their infants: Recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR. Recommendations and Reports, 57*(RR-4), 1–51.

Mussa, A., Wynn, A., Ryan, R., Babalola, C. M., Hansman, E., Simon, S., Bame, B., Tamuthiba, L., Ramontshonyana, K., Ndlovu, N., Moshashane, N., Masole, M., Klausner, J. D., & Morroni, C. (2023). Prevalence of *Chlamydia trachomatis* and *Neisseria gonorrhoeae* infection and associated factors among asymptomatic pregnant women in Botswana. *International Journal of STD & AIDS, 34*(7), 448–456. https://doi.org/10.1177/09564624231163203

Olaleye, A. O., Babah, O. A., Osuagwu, C. S., Ogunsola, F. T., & Afolabi, B. B. (2020). Sexually transmitted infections in pregnancy—An update on *Chlamydia trachomatis* and *Neisseria gonorrhoeae*. *European*

Journal of Obstetrics, Gynecology, and Reproductive Biology, 255, 1–12. https://doi.org/10.1016/j.ejogrb.2020.10.002

Ramazani Tabora, J., Okenge Ngongo, L., Tshimungu Katshidikaya, F., Omanyongo Ohambe, M.-C., Ramazani Bongolu, B., Shongo Onasaka, L., & Bale Isemighambo, A. (2022). Determinants of neonatal mortality in Kisangani hospital settings. *International Journal of Progressive Sciences and Technologies, 34*(1), 220. https://doi.org/10.52155/ijpsat.v34.1.4569

Ravindran, J., Richardson, B. A., Kinuthia, J., Unger, J. A., Drake, A. L., Osborn, L., Matemo, D., Patterson, J., McClelland, R. S., & John-Stewart, G. (2021). Chlamydia, gonorrhea, and incident HIV infection during pregnancy predict preterm birth despite treatment. *The Journal of Infectious Diseases, 224*(12), 2085–2093. https://doi.org/10.1093/infdis/jiab277

Sartorius, V., Philibert, M., Klungsoyr, K., Klimont, J., Szamotulska, K., Drausnik, Z., Velebil, P., Mortensen, L., Gissler, M., Fresson, J., Nijhuis, J., Zhang, W.-H., Källén, K., Rihs, T. A., Tica, V., Matthews, R., Smith, L., Zeitlin, J., & Euro-Peristat Network. (2024). Neonatal mortality disparities by gestational age in European countries. *JAMA Network Open, 7*(8), e2424226. https://doi.org/10.1001/jamanetworkopen.2024.24226

Tekeba, B., Tamir, TT, Workneh, BS, Zegeye, AF, Gonete, AT, Alemu, TG, Wassie, M., Kassie, AT, Ali, MS, & Mekonen, EG (2024). Early neonatal mortality and determinants in Ethiopia : Multilevel analysis of Ethiopian demographic and health survey, 2019. *BMC Pediatrics , 24* (1), 558. https://doi.org/10.1186/s12887-024-05027-z

Ukah, UV, Côté-Corriveau, G., Nelson, C., Healy-Profitós, J., & Auger, N. (2024). Risk of Adverse Neonatal Events in Pregnancies Complicated by Severe Maternal Morbidity. *The Journal of Pediatrics , 273* , 114149. https://doi.org/10.1016/j.jpeds.2024.114149