Italian Journal of Pediatrics

RESEARCH

Open Access

Individual and community level determinants of neonatal mortality in sub saharan Africa: findings from recent demographic and health survey data

Engidaw Fentahun Enyew[1,2*], Mihret Getnet[3,4], Ashebir Mamay Gebiru[4,5] and Gashaw Dessie[6]

Abstract

Background A major cause of deaths among children under five is neonatal mortality, a worldwide problem. However, the problem in sub-Saharan Africa is not well documented. Understanding the prevalence of neonatal death and its related causes is crucial for creating efforts and policies that could help address the problem. This study set out to determine the prevalence of neonatal death and its determinants in sub-Saharan Africa.

Methods Using secondary data analysis of demographic and health surveys conducted between 2014 and 2024 in sub-Saharan Africa. Total weighted samples of 133,448 live births in all during the period in 31 Sub- Saharan Africa. The determinants of neonatal mortality were identified using a multilevel mixed-effects logistic regression model. A multilevel binary logistic regression was fitted to identify the significant determinants of neonatal mortality. The Intra-class Correlation Coefficient, Median Odds Ratio, Proportional Change in Variance was used for assessing the clustering effect, and deviance for model comparison. Variables with a p-value < 0.2 in the Bivariable analysis were considered in the multivariable analysis. In the multivariable multilevel binary logistic regression analysis, Adjusted Odds Ratio with 95% CI was reported to declare statistically significant determinants of neonatal mortality.

Results The neonatal mortality in sub-Saharan Africa was 32 per 1000 live births (95% CI: 30, 34). maternal occupation (AOR = 1.26, 95% CI: 1.16, 1.37), home delivery (AOR = 1.29; 95% CI: 1.21, 1.39), caesarean section (AOR = 1.58; 95%CI: 1.36, 1.83), twin births(AOR = 2.48, 95% CI: 2.05, 2.54), birth order of 2–4 (AOR = 1.30, 95% CI: 1.18, 1.44), birth order of ≥ 5 (AOR = 1.43, 95% CI: 1.31, 1.59) and smaller size than average (AOR = 1.49, 95% CI: 1.36, 1.63)were significantly associated with higher odds of neonatal mortality.

Conclusion According to this study, in sub-Saharan Africa neonatal mortality rate was high. The following factors should be taken into account while developing policies and measures to reduce newborn mortality in sub-Saharan Africa: the mother's education, wealth index, occupation, place of delivery, mode of delivery, twin birth, neonatal sex, birth order, and size at birth.

*Correspondence:
Engidaw Fentahun Enyew
engdaw212@gmail.com
Full list of author information is available at the end of the article

Introduction

The neonatal mortality rate is defined as the number of deaths per 1000 live births in the first 28 days after birth [1]. Globally, 2.3 million children died in the first month of life in 2022, approximately 6,300 neonatal deaths every day and decreased by 44% since 2000 [2]. Yet in 2022, nearly half (47%) of all deaths in children under 5 years of age occurred in the first 28 days of life [3].

Even if the worldwide neonatal mortality rate is dropping, there are notable differences in neonatal mortality between countries and regions.

Sub-Saharan Africa(SSA) has the highest newborn mortality rate in the region, with an expected 27 deaths per 1,000 live births in 2022 [2, 3]. It is far below to achieve the Sustainable Development Goal (SDG) target of reducing the neonatal mortality rate of 12 or less per 1000 live births by 2030 [4].

Most neonatal deaths (75%) occur during the first week of life, and about 1 million newborns die within the first 24 h [3]. Among neonates, the leading causes of death include premature birth, birth complications (birth asphyxia/trauma), neonatal infections and congenital anomalies, which collectively account for almost 4 in every 10 deaths in children under 5 years of age [5, 6]. It is worth noting that although the rates for the leading causes of neonatal deaths have declined globally since 2000, they accounted for the same proportion of under-5 deaths 4 in 10 in 2000 and 2022 [3].

Previous studies have shown that the following factors are statistically associated with neonatal mortality in sub-Saharan countries: maternal education, deliveries without a skilled care provider, pregnancy complications, birth weight, household wealth status, and a lack maternal continuum of care utilization [7–12].

Neonatal mortality is still a major public health concern because it accounts for a substantial amount of under-5 deaths in different regions. Ironically, neonatal health has gotten less attention than rates of under-5 mortality [13]. Our study aims to address this gap by investigating neonatal mortality rates among neonates in sub Saharan Africa [14].

Our analysis of this age group helps us better understand neonatal health outcomes and pinpoints possible risk factors for neonatal death. In order to close the knowledge gap, our research aims to shed light on neonatal death and contributing variables, specifically in neonates. In order to create focused initiatives and well-informed policy solutions, this understanding is essential. Importantly, our research confirms the idea that neonatal mortality has a major effect on child survival in sub-Saharan Africa [15].

Methods

Data source, study setting and population

The secondary data analysis of recent SSA Demographic Health Survey datasets from 2014 to 2024 was conducted. The datasets were appended together to investigate neonatal mortality and determinants in SSA. The study included a total of 31 countries that had standard Demographic and Health Surveys (DHS) during this specified time period. The DHS are surveys that are nationally representative and offer data that is comparable across nations to monitor and assess impact indicators in the areas of population, health, and nutrition. The DHS uses a two-stage stratified cluster sampling technique. The first stage is to select enumeration areas, and the second stage is to draw a sample of households in each enumeration area. The list of countries included in the analysis comprises Angola, Benin, Burkina Faso, Burundi, Cameroon, Chad, Congo Democratic Republic, Cote d'Ivoire, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Nigeria, Rwanda, Sierra Leone, South Africa, Tanzania, Togo, Uganda, Zambia, Zimbabwe. The data were accessed from the official Demographic Health Survey program database (http://www.dhsprogram.com).

This study used the children's record dataset to determine the outcome variable. A sample of 133,448 live births was included in the study. While all babies born alive from women of reproductive age five years before the surveys in sub-Saharan Africa were the source population, all live births in the enumeration areas of the survey were the study population.

Study variables

Outcome variables

The outcome variable for this study was neonatal death as reported by the mother, and it was defined as the death of a neonate within the first months of birth. Which was dichotomized neonatal death (1 = if death occurs in the first month of life) or alive (0 = if the newborn alive in the first month of life).

Independent variables

Considering the hierarchical DHS data, two-level explanatory variables (individual and community) were used to identify the determinants of neonatal mortality. The individual-level variables included place of residence, maternal age, marital status, maternal education, wealth index, maternal occupation, sex of neonate, mode of delivery, birth order, place of delivery, type of birth, antenatal care visit(ANC), distance from the health facility and size neonate at birth. Whereas, community-level variables included community media exposure, community poverty level and community education level.

Media exposure was measured from three variables such as reading the newspaper, listening to the radio, watching television and use internet. These variables were merged and categorized as no "when there was no exposure to either of the four" and yes "when there was exposure to either of reading newspaper, listening radio, watching television and internet". Birth weight was categorized as small, average, and large size at birth reported by the mother. The individual-level variables of maternal education and household wealth index, respectively, were grouped to determine the community levels of education and poverty.

Data management and analysis

The variables were extracted from the BR file dataset using STATA version 17 statistical software. The weighted data were used for analysis to adjust for unequal probability of selection and non-response. Because DHS data is hierarchical in nature, a multilevel mixed effect logistic regression model was applied to assess determinants of neonatal mortality in SSA.

Multilevel mixed effect logistic regression has four models; the null model, model I, model.

II, and model III. Null model is used to determine the applicability of multilevel to the data by determining measure of variation. Model I uses to determine the effect of only individual level factors on neonatal mortality. Model II uses to determine the effect of community level factors on neonatal mortality. The last model (model III) shows the effects of both individual and community level factors on the neonatal mortality.

The measurement of variation (random effect) was done using the median odds ratio (MOR), intra-cluster correlation coefficient (ICC), and proportional change in variation (PCV). The MOR is the unexplained heterogeneity of neonatal mortality between clusters, and it shows the odds of variation in neonatal mortality between high- and low-risk clusters, taking two clusters at random. ICC indicates the percent of variation in neonatal mortality between clusters, and PCV is the precents of variation in neonatal mortality attributed to individual and community-level factors.

The measure of association or fixed effect was determined by the computation of the AOR at 95% CI and p-value. The best-fit model was selected by using deviance and log likelihood ratio (LLR). A model with a small value of deviance (-2×LLR) and a large value of log likelihood ratio was taken as the best fit.

Results

The analysis included a weighted sample of 133,448 neonates in total. 98,071 (73.49%) of the mothers lived in rural areas, while 85,860 (64.34%) of the mothers of neonates were between the ages of 35 and 49. Of all neonates, 65,617 (58.55%) of their mothers have been exposed to the media. From a total of 133, 448 neonates, 54.51% were males and 56.59% were born at health facility. Similarly, 95.13% were delivered through vaginal delivery. About 8.13% were twin births and 44.76% were average size at birth (Table 1).

Prevalence of neonatal mortality in Sub-Saharan Africa

The prevalence of neonatal mortality among neonates born to mothers in sub Saharan Africa was found to be 32 neonatal deaths per 1000 live births at a 95% CI [30, 34]. The high rate of neonatal mortality (49 neonatal deaths per 1000 live births) was observed in Mauritania and lowest in the chad (20 per 1000 live births) of the DHS data (Fig. 1).

Measure of variation and model fit statistics

As shown in Table 2 below, 5.2% of the variation in neonatal mortality happened between clusters, and the rest of the variation occurred within clusters (ICC = 5.2%). The MOR in the null model shows that the odds of neonatal mortality were 1.80 times higher among clusters of high risk for mortality compared to clusters of low risk for mortality. In model I, about 35.2% of the variation in neonatal mortality was attributed to individual-level factors (PCV = 35.2%). In the model III, 59.6% of the variation in neonatal mortality was due to both individual and community-level factors included in the regression. The odds of neonatal mortality were 1.90% times higher among high-risk clusters compared to low-risk clusters (MOR = 1.90% in model III). According to the model fitness analysis of this study, model III had the lowest deviance and a large LLR value, which indicated that it was the best fitted model.

Measures of associations of neonatal mortality in Sub Saharan Africa

A total of seventeen variables were included in multilevel analysis to identify determinants of neonatal mortality in SSA. Namely; place of residence, maternal age, maternal education, household wealth index, marital status, women's occupation, sex of neonate, place of delivery, mode of delivery, type of pregnancy, birth order, and size of children at birth, distance at health facility, ANC visit, community media exposure, community education level and community poverty level.

In the multivariable analysis; maternal education, household wealth index, women occupation, sex of neonates, place of delivery, mode of delivery, twin births, birth order, size of neonate at birth and community media exposure were significantly associated with neonatal mortality.

The odds of neonatal mortality among live births born to mothers who attained primary, and secondary

Table 1 Socio-demographic and obstetric characteristics of study subjects

Variables	Frequency (*N* = 133,448)	Percentage (%)
Individual level factors		
Residence		
Urban	35,377	26.51
Rural	98,071	73.49
Maternal age (years)		
15–24	8,754	6.56
25–34	38,834	29.10
35–49	85,860	64.34
Maternal education level		
No education	69,609	52.16
Primary	45,081	33.78
Secondary	18,758	14.06
Wealth status		
Poor	68,664	51.45
Medium	27,520	20.62
Rich	37,264	27.92
Marital status		
Single	3,669	2.75
Married	112,164	84.05
Widowed/divorced/separated	17,615	13.20
Women's occupation status		
not working	27,042	20.88
working	102,461	79.12
Sex of neonate		
Male	72,743	54.51
Female	60,705	45.49
Place of delivery		
Home	8,178	43.41
Health facility	10,660	56.59
Mode of delivery		
Vaginal	17,992	95.13
Caesarean section	922	4.87
Type of birth		
Single	122,597	91.87
Twin	10,851	8.13
Total children ever born		
< 4	34,490	25.85
> 4	98,958	74.15
Size of neonate at birth		
Small	4,432	23.76
Average	8,350	44.76
Large	5,871	31.47
Distance to health facility		
Big problem	55,527	44.25
Not a big problem	69,948	55.75
ANC visit		
No	1,800	19.85
Yes	7,269	80.15
Community level variables		
Community Media exposure		
No	46,455	41.45
Yes	65,617	58.55
Community poverty		

Table 1 (continued)

Variables	Frequency (*N* = 133,448)	Percentage (%)
Low	67, 758	50.77
high	65, 690	49.22
Community women education		
Low	67, 559	50.61
High	65, 889	49.37

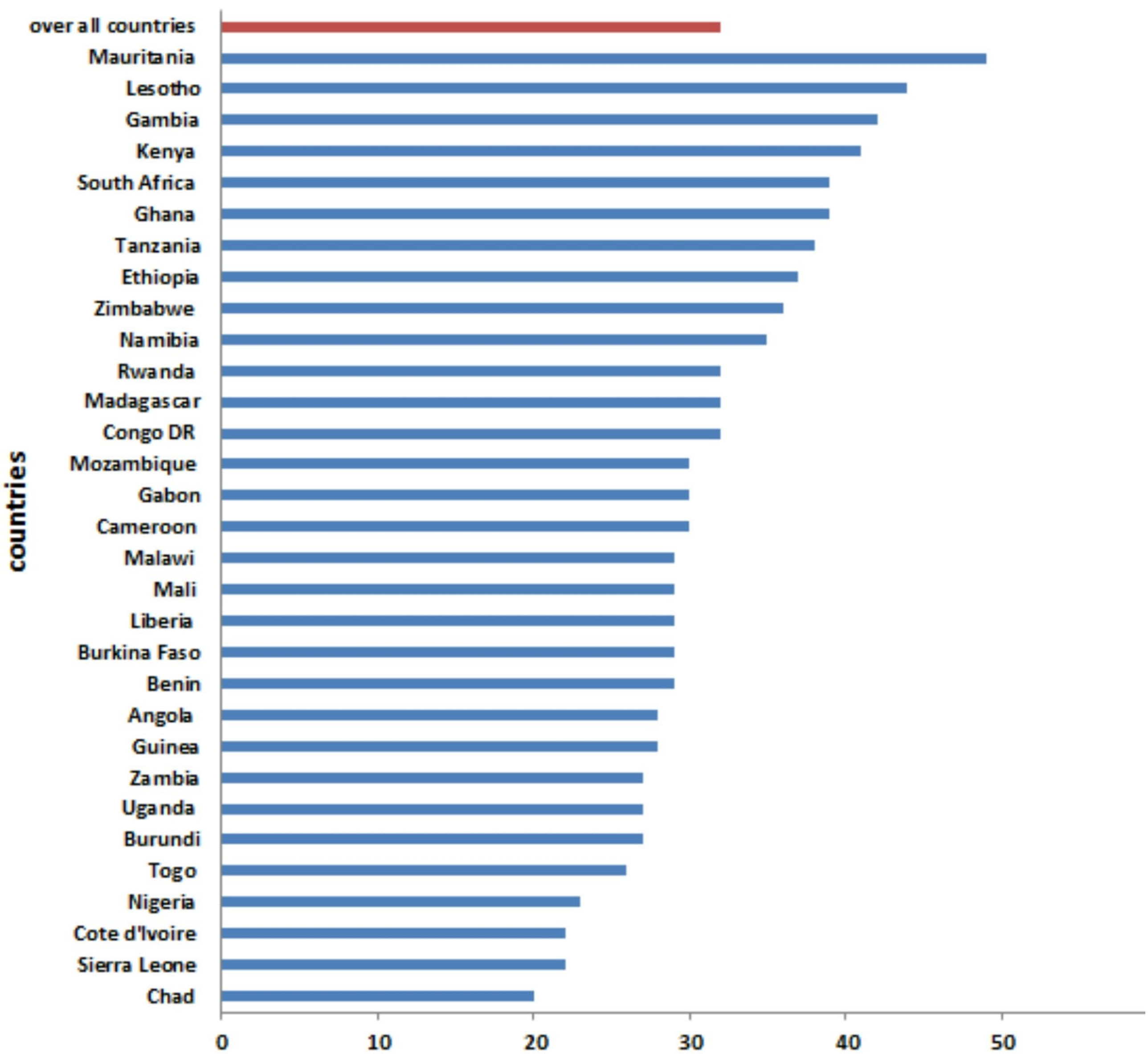

Fig. 1 Prevalence of neonatal mortality in sub Saharan Africa, 2014–2014
Neonatal mortality in sub-Saharan Africa: 32 deaths per 1000 live births (95% CI: 30–34). Mauritania had the highest rate (49/1000 live births), while Chad had the lowest (20/1000 live births) based on DHS data

education were decreased by 60%(AOR = 0.40, 95% CI: 0.27, 0.54) and 85% (AOR = 0.15, 95% CI: 0.06, 0.24) compared with not attained formal education.

Neonatal mortality among live births born to women medium and rich household wealth index were decreased by 75% (AOR = 0.25, 95% CI: 0.14, 0.37) and 91%(AOR = 0.09, 95%CI: 0.01, 0. 20) as compared counterpart, respectively. Neonatal mortality was 1.26 (AOR = 1.26, 95%CI: 1.16, 1.37) times higher than women who were not employed than employed women. The odds of

Table 2 Measure of variation and model fit of neonatal mortality in sub-Saharan Africa

Parameters	Null model	Model I	Model II	Model III
Measures of association				
Variance	0.0876002	0.1760344	0.0818796	0.1722344
ICC	5.2%	5%	4.2%	4.9%
MOR	1.80	1.98	1.37	1.90
PCV	Reference	35.2%	25.3%	59.6%
Model fitness				
LLR	-85,325	-11,737	-85,278	-11,734
Deviance	41,304 0.1	2286.4	41245.4	2254.4

ICC: intra-cluster correlation coefficient, MOR: median odds ratio, PCV: proportional change in variance and LLR: log likelihood ratio

neonatal mortality among female births were decreased by 21% (AOR = 0.79, 95% CI: 0.74, 0.84) compared to male births.

For babies delivered in home and by caesarean section, the odds of neonatal mortality were 1.29(AOR = 1.29; 95% CI: 1.21, 1.39) and 1.58(AOR = 1.58; 95%CI: 1.36, 1.83) times higher compared to babies delivered in health facility and not by caesarean section, respectively. The odds of neonatal mortality among twin births were 2.48 (AOR = 2.48, 95% CI: 2.05, 2.54) times higher compared to singletons.

Furthermore, the odds of neonatal mortality was 1.30 (AOR = 1.30, 95%CI: 1.18, 1.44) and 1.43(AOR = 1.43, 95%CI: 1.31, 1.59) times higher among women who had 2–4 and greater than four birth order with their counterparts. The odds of neonatal death for neonates with lower than average was 1.49 (AOR = 1.49, 95% CI: 1.36, 1.63) times higher than neonates with average size at birth. Lastly, the odds of neonatal mortality was decrease by 9% (AOR = 0.91, 95% CI: 0.83, 0.99) as compared community media exposure with the counterpart(Table 3).

Discussion

A major global public health concern is neonatal mortality, particularly in in developing countries like sub-Saharan Africa. In order to ascertain the prevalence and contributing determinants of neonatal death in sub-Saharan Africa, this study used data from the most recent demographic and health survey.

The prevalence of neonatal mortality in this study was 32 deaths per 1000 live births, with a 95% CI of [30, 34]. The prevalence of neonatal mortality in this study were higher than the average global rate of 17 neonatal deaths per 1000 live births [16] and mothers at extreme ages of reproductive life in low- and middle-income countries of 28.96 neonatal deaths per 1000 live births [15]. This suggests that the incidence of neonatal mortality in SSA was approximately threefold greater than the 2030 SDG target, which calls for bringing the rate down to 12 or less per 1000 live births [17]. This could be due to the various health policies implemented in the countries as well as different levels of economic status of the countries.

Based on our study, maternal education, household wealth index, maternal occupation, sex of neonates, place of delivery, mode of delivery, twin births, birth order, size of neonate at birth and community media exposure were significantly associated with neonatal mortality.

Our findings indicate that the probability of neonatal death is higher among mothers with primary education or no education, in comparison to those with secondary education and above. This finding agrees with findings from previous studies [15, 18, 19]. Globally, there is support for the positive effects of maternal education on newborn survival [18, 20]. Despite adjusting for other neonatal mortality risks, maternal education is still crucial for a child's survival [20]. Mothers' healthcare-seeking behaviours are improved and their knowledge of a child's health and healthcare facilities is increased through maternal education [21, 22].

This study found that, in comparison to their counterparts, being born into a medium-income or rich household lowers the likelihood of neonatal death by 22% and 17%, respectively. This finding is similar with studies conducted in South Asia [23],Ghana [24]and in Ethiopia [25]. It might be argued that the high neonatal mortality rate in low-income families were caused by a number of factors, including limited access to high-quality healthcare, maternal malnutrition that can lead to complications, poor living and sanitation conditions that can increase maternal infection, and a lack of knowledge and awareness about the risks of pregnancy.

In this study, neonatal mortality was substantially associated with the occupation of the mother. In light of this, babies born to mothers without jobs had a higher mortality rate than babies born to mothers with jobs. similar findings for a study conducted in Ethiopia [26].

In contrast, a study conducted in India found that infants born to unemployed mothers had a reduced chance of neonatal death than those delivered to employed mothers [27]. The socioeconomic and sociodemographic position of the mothers may be the cause of these conflicting results, since employed mothers earn more money and have higher levels of education than jobless mothers. Additional data indicated that mother income and educational attainment were substantially correlated with neonatal mortality [28].

Compared to their male counterparts, female neonates have a higher biological chance of surviving. Male neonates are more prone to have respiratory distress syndrome because the lungs of male fetus develop more slowly than those of female fetus [29]. Globally, it is estimated that approximately 23% of newborn deaths are attributed to respiratory problems [30]. According to research, male newborns are more susceptible to

Table 3 Measures of associations of neonatal mortality in Sub Saharan Africa

Individual and community level Variables determinants	Model I AOR(95% CI)	Model II AOR(95% CI)	Model III AOR(95% CI)
Residence			
Urban	1		1
Rural	0.98(0.90, 1.07)		1.01(0 0.92, 1.09)
Maternal age (years)			
15–24	0.87 0.79, 0.95)		0.85(0 0.78, 0 0.100)
25–34	0.90(0.80, 1.01)		0 0.89(0 0.79, 1.04)
35–49	1		1
Maternal education level			
No education	1		1
Primary	0.42(0.29, 0.56)		0.40(0.27, 0.54) *
Secondary	0.16(0.07, 0.25)		0.15(0 06, 0.24) *.
Household Wealth index			
Poor	1		
Medium	0.26(0.14, 0.39)		0.25(0 0.14, 0.37) *
Rich	0.11(0.01, 0.22)		0.09(0 0.01, 0.20) *
Marital status			
Married	1		1
Single	1.56(1.46, 1.66)		1.05(0.91, 1.22)
Widowed/divorced/separated	0.92(0.89, 0.95)		0.84(0.74, 1.07)
Women's occupation status			
working	1		1
Not working	1.22(1.19, 1.26)		1.26(1.16, 1.37)*
Sex of neonate			
Male	1		1
Female	0.80(0.75, 0.85)		0.79(0.74, 0.84) *
Place of delivery			
Health facility	1		1
Home	1.30(1.21, 1.40)		1.29(1.21, 1.39) *
Mode of delivery			
Vaginal	1		1
Caesarean section	1.58(1.36, 1.83)		1.58(1.36, 1.83) *
Type of birth			
Single	1		1
Twin	2.29(2.05, 2.55)		2.48(2.05, 2.54) *
Birth order			
First birth	1		1
<4	1.22(1.18,1.25)		1.30(1.18, 1.44)*
>4	1.40(1.36, 1.43)		1.43(1.31, 1.59) *
Size of neonate at birth			
Small	1.22(1.19, 1.26)		1.49(1.36, 1.63) *
Average	1		1
Large	0.91(0.85,0.98)		0.97(0.90, 1.06)
Distance to health facility			
Big problem	1		1
Not a big problem	0.96(0.89, 1.03)		0.95(0.89, 1.02)
ANC visit			
No	1		1
Yes	0.98(0.89, 1.01)		0.96(0.86, 1.07)
Community Media exposure			
No		1	1
Yes		0.91(0.88, 0.95)	0.91(0.83, 0.99) *
Community poverty			

Table 3 (continued)

Individual and community level Variables determinants	Model I AOR(95% CI)	Model II AOR(95% CI)	Model III AOR(95% CI)
Low		1	1
high		0.91(0.86, 0.95)	1.03(0.93, 1.13)
Community women education			
Low		1	1
High		1.11(1.06,1.17)	1.02(0.94, 1.12)

*: level of significance (p value) less than 0.05

perinatal conditions like birth trauma, fetal macrosomia, birth asphyxia, prematurity, and respiratory distress syndrome, as well as congenital defects and infectious diseases like intestinal and lower respiratory infections [31–33]. Nevertheless, it is still unclear what underlying mechanisms are responsible for the reported masculine disadvantage.

According to our study, babies born at home were more likely to neonatal mortality as newborns than those born in healthcare facilities. This study supported various studies [15, 34–36]. Higher neonatal mortality was found among children born at home [37]. This is as a result of the health-seeking behaviour where most deliveries will be attended to at home until it becomes complicated. Additionally, the study contends that expanding facility delivery in places where home delivery is prevalent, encouraging the use of medical facilities during labor, and creating supportive environments are all crucial [35].

Compared to vaginal deliveries, mothers who had caesarean sections had a greater chance of neonatal mortality, which may have been caused by iatrogenic prematurity or potentially fatal pregnancy problems that warranted an emergency caesarean surgery [38]. In contrast to our findings, however, a cross-sectional ecological study found that the rates of caesarean deliveries were negatively association with neonatal mortality [39], and another ecological study found that caesarean sections for high-risk pregnancies could help improve neonatal outcomes [40].

Compared to singleton births, twin births had a greater chance of neonatal death. This study was supported by a study conducted in Ghana [41], in SSA [15], in Ethiopia [42, 43].This could be since twin births are at higher risk of preterm delivery and fetal growth restriction and this could increase their risk of hypothermia, and hypoglycaemia that might increase the risk of neonatal mortality [24, 44, 45]. Furthermore, low birth weight is a common result of twin pregnancies, which makes children more susceptible to infection and affects their immune systems [46]. Consequently, there is a decline in neonatal survival.

According to this study, birth order significantly impacted neonatal mortality in sub-Saharan Africa. A higher neonatal birth order was associated with a higher risk of neonatal mortality. As birth orders increase, it is expected that the amount of child care will decrease because the mother will have more children to look after. This finding is consistent with the findings of earlier research [47, 48].

In comparison to neonates who were average in size at delivery, mothers who thought their babies were small at birth were more likely to die during the first month of life. It was consistent with previous studies [49, 50]. Furthermore, small size babies are more prone to hypothermia, and infection, this could lead to the death of the neonate [51]. Poor healthcare-seeking behaviour by mothers and families for neonatal health issues may be the cause of the higher risk of mortality among low-birth-weight babies [52, 53]. Low birth weight neonates under one month of age may be at greater risk of dying due to a lack of child healthcare services and their subpar condition [54].

According to this study, exposure to community media significantly determinant of neonatal death. Compared to newborns from the community with low media exposure, those from the community with high media exposure had lower odds of death during the neonatal period. This is consistent with a study conducted in Bangladesh [55] and I Ethiopia [44], and it could be because mothers who were exposed to the media were more knowledgeable about the use of ANC, institutional delivery, and childhood disease [56].

Limitations of the study

Although this study were the utilization of nationally gathered large samples of recent health and demographic survey data from sub-Saharan African countries. Some SSA that had not conducted a health or demographic survey before 2014 were left out, though, which would have limited how broadly applicable our findings were. Furthermore, the research employed DHS data gathered in several years, thus subjecting the study's conclusions to the differential time effect.

Conclusion

According to this study, in sub-Saharan Africa, neonatal mortality was high. When developing policies and strategies aimed at reducing neonatal mortality in sub-Saharan Africa, factors such as maternal education, maternal occupation, and household wealth index, sex of neonates, multiple pregnancies, and place of delivery, mode of delivery, birth order, size at birth and community media exposure should be taken into account.

Acknowledgements
The authors acknowledged the DHS program office to take ethical consideration of this study.

Author contributions
EFE: Conceptualization, data curation, formal analysis, investigation, methodology, resources, software, validation, visualization, Writing– original draft, Writing, MG: Data curation, investigation, methodology, review & editing. AMG: Data curation, investigation, methodology, resources, validation, visualization, writing– review & editing. GD: Data curation, investigation, methodology, resources, validation, visualization, writing– review & editing. Both the authors read and approved the final manuscript.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability
Data for this study were obtained from the DHS Program.

Declarations

Ethical approval and consent to participate
Ethical approval and permission letter were requested online to the DHS program at www.dhsprogram.com to access the data for this study, and the DHS program was granted permission through email. The data used in this study was freely available and did not contain any personal information. The research is done based on secondary data from DHS. Issues of informed consent, confidentiality, anonymity and privacy of the study sample were already done ethically by the DHS authority and we did not manipulate and use the data for other issues. There was no patient or public involvement in this study.

Consent for publication
Not applicable.

Competing interests
The authors declare no conflict of interest.

Author details
[1]Department of Anatomy, School of Medicine, College of Medicine and Health Science, University of Gondar, Gondar, Ethiopia
[2]Department of Reproductive Health, Institute of Public Health, College of Medicine and Health Science, University of Gondar, Gondar, Ethiopia
[3]Department of Human Physiology, School of Medicine, College of Medicine and Health Sciences, University of Gondar, Gondar, Ethiopia
[4]Department of Epidemiology and biostatistics, Institute of public Health, College of Medicine and Health Sciences, University of Gondar, Gondar, Ethiopia
[5]Departments of Health informatics Gondar, Teda Health Science College, Gondar, Ethiopia
[6]Department of Biochemistry, School of Medicine, College of Medicine and Health Sciences, University of Gondar, Gondar, Ethiopia

Received: 24 January 2025 / Accepted: 11 May 2025
Published online: 19 May 2025

References

1. Organization WH. WHO technical consultation on newborn health indicators: every newborn action plan metrics, Ferney Voltaire, France, 3–5 December 2014. WHO technical consultation on newborn health indicators: every newborn action plan metrics, Ferney Voltaire, France, 3–5 December 20142015.
2. United Nations Inter. -agency group for child mortality Estimation. UN IGME); 2024.
3. World health organization (WHO). March 14, 2024.
4. Kc A, Jha AK, Shrestha MP, Zhou H, Gurung A. Trends for Neonatal Deaths in Nepal (2001–2016) to Project Progress Towards the SDG Target in 2030, and Risk Factor Analyses to Focus Action. 2020;24(Suppl 1):5–14.
5. Wardlaw T, You D, Hug L, Amouzou A, Newby H. UNICEF report: enormous progress in child survival but greater focus on newborns urgently needed. Reproductive Health. 2014;11(1):82.
6. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, et al. Global, regional, and National causes of under-5 mortality in 2000-15: an updated systematic analysis with implications for the sustainable development goals. Lancet (London England). 2016;388(10063):3027–35.
7. Yaya Y, Eide KT, Norheim OF, Lindtjørn B. Maternal and neonatal mortality in south-west Ethiopia: estimates and socio-economic inequality. PLoS ONE. 2014;9(4):e96294.
8. Akinyemi JO, Bamgboye EA, Ayeni O. Trends in neonatal mortality in Nigeria and effects of bio-demographic and maternal characteristics. BMC Pediatr. 2015;15:1–12.
9. Titaley CR, Dibley MJ, Agho K, Roberts CL, Hall J. Determinants of neonatal mortality in Indonesia. BMC Public Health. 2008;8:1–15.
10. Reyes JL, Ramírez RP, Ramos LL, Ruiz LG, Vázquez EB, Patino VR. Neonatal mortality and associated factors in newborn infants admitted to a neonatal care unit. Arch Argent Pediatr. 2018;116(1):42–8.
11. Organization WH. Reaching the every newborn national 2020 milestones: country progress, plans and moving forward. 2017.
12. Dahiru T. Determinants of early neonatal mortality in Nigeria: results from 2013 Nigeria DHS. J Pediatr Neonatal Care. 2015;2(5):1015406.
13. Tamir TT, Asmamaw DB, Negash WD, Belachew TB, Fentie EA, Kidie AA et al. Prevalence and determinants of early neonatal mortality in Ethiopia: findings from the Ethiopian demographic and health survey 2016. BMJ Paediatrics Open. 2023;7(1).
14. Lawn JE, Cousens S, Zupan J. 4 Million neonatal deaths: when?? when?re? Why? Lancet. 2005;365(9462):891–900.
15. Tamir TT. Neonatal mortality rate and determinants among births of mothers at extreme ages of reproductive life in low and middle income countries. Sci Rep. 2024;14(1):12596.
16. UNICEF. Neonatal mortality. 2024.
17. Boerma T, Requejo J, Victora CG, Amouzou A, George A, Agyepong I, et al. Countdown to 2030: tracking progress towards universal coverage for reproductive, maternal, newborn, and child health. Lancet. 2018;391(10129):1538–48.
18. Islam MA, Butt ZA, Sathi NJ. Prevalence of neonatal mortality and its associated factors: A Meta-analysis of demographic and health survey data from 21 developing countries. Dr Sulaiman Al Habib Med J. 2022;4(3):145–52.
19. Islam MA, Biswas B. Socio-economic factors associated with increased neonatal mortality: a mixed-method study of Bangladesh and 20 other developing countries based on demographic and health survey data. Clin Epidemiol Global Health. 2021;11:100801.
20. Gakidou E, Cowling K, Lozano R, Murray CJ. Increased educational attainment and its effect on child mortality in 175 countries between 1970 and 2009: a systematic analysis. Lancet. 2010;376(9745):959–74.
21. Güneş PM. The role of maternal education in child health: evidence from a compulsory schooling law. Econ Educ Rev. 2015;47:1–16.
22. Amoah A, Asamoah M. Child survival: the role of a mother's education. Heliyon, 8 (11), e11403. 2022.
23. Nair N, Tripathy P, Prost A, Costello A, Osrin D. Improving newborn survival in low-income countries: community-based approaches and lessons from South Asia. PLoS Med. 2010;7(4):e1000246.
24. Lartey ST, Khanam R, Takahashi S. The impact of household wealth on child survival in Ghana. J Health Popul Nutr. 2016;35:1–16.
25. Fenta SM, Biresaw HB, Fentaw KD. Risk factor of neonatal mortality in Ethiopia: multilevel analysis of 2016 demographic and health survey. Trop Med Health. 2021;49:1–11.
26. Alebel A, Wagnew F, Petrucka P, Tesema C, Moges NA, Ketema DB, et al. Neonatal mortality in the neonatal intensive care unit of Debre Markos referral hospital, Northwest Ethiopia: a prospective cohort study. BMC Pediatr. 2020;20:1–11.
27. Singh A, Kumar A, Kumar A. Determinants of neonatal mortality in rural India, 2007–2008. PeerJ. 2013;1:e75.
28. Karlsen S, Say L, Souza J-P, Hogue CJ, Calles DL, Gülmezoglu AM, et al. The relationship between maternal education and mortality among women giving birth in health care institutions: analysis of the cross sectional WHO global survey on maternal and perinatal health. BMC Public Health. 2011;11:1–10.

29. Khoury MJ, Marks JS, McCarthy BJ, Zaro SM. Factors affecting the sex differential in neonatal mortality: the role of respiratory distress syndrome. Am J Obstet Gynecol. 1985;151(6):777–82.
30. Mathers C. The global burden of disease: 2004 update. World Health Organization; 2008.
31. Zhao D, Zou L, Lei X, Zhang Y. Gender differences in infant mortality and neonatal morbidity in mixed-gender twins. Sci Rep. 2017;7(1):8736.
32. Hou L, Wang X, Li G, Zou L, Chen Y, Zhang W. Cross sectional study in China: fetal gender has adverse perinatal outcomes in Mainland China. BMC Pregnancy Childbirth. 2014;14:1–8.
33. Aibar L, Puertas A, Valverde M, Carrillo MP, Montoya F. Fetal sex and perinatal outcomes. 2012.
34. Ajaari J, Masanja H, Weiner R, Abokyi SA, Owusu-Agyei S. Impact of place of delivery on neonatal mortality in rural Tanzania. Int J MCH AIDS. 2012;1(1):49.
35. Tura G, Fantahun M, Worku A. The effect of health facility delivery on neonatal mortality: systematic review and meta-analysis. BMC Pregnancy Childbirth. 2013;13:1–9.
36. Chaka EE, Mekurie M, Abdurahman AA, Parsaeian M, Majdzadeh R. Association between place of delivery for pregnant mothers and neonatal mortality: a systematic review and meta-analysis. Eur J Pub Health. 2020;30(4):743–8.
37. Chen W-H, Su C-H, Lin L-C, Lin H-C, Lin Y-J, Hsieh H-Y, et al. Neonatal mortality among outborn versus inborn babies. Pediatr Neonatology. 2021;62(4):412–8.
38. Xie Rh, Gaudet L, Krewski D, Graham ID, Walker MC, Wen SW. Higher Cesarean delivery rates are associated with higher infant mortality rates in industrialized countries. Birth. 2015;42(1):62–9.
39. Molina G, Weiser TG, Lipsitz SR, Esquivel MM, Uribe-Leitz T, Azad T, et al. Relationship between Cesarean delivery rate and maternal and neonatal mortality. JAMA. 2015;314(21):2263–70.
40. Althabe F, Sosa C, Belizán JM, Gibbons L, Jacquerioz F, Bergel E. Cesarean section rates and maternal and neonatal mortality in low-, medium-, and high-income countries: an ecological study. Birth. 2006;33(4):270–7.
41. Kayode GA, Ansah E, Agyepong IA, Amoakoh-Coleman M, Grobbee DE, Klipstein-Grobusch K. Individual and community determinants of neonatal mortality in Ghana: a multilevel analysis. BMC Pregnancy Childbirth. 2014;14:1–12.
42. Wolde HF, Gonete KA, Akalu TY, Baraki AG, Lakew AM. Factors affecting neonatal mortality in the general population: evidence from the 2016 Ethiopian demographic and health survey (EDHS)—multilevel analysis. BMC Res Notes. 2019;12:1–6.
43. Baraki AG, Akalu TY, Wolde HF, Lakew AM, Gonete KA. Factors affecting infant mortality in the general population: evidence from the 2016 Ethiopian demographic and health survey (EDHS); a multilevel analysis. BMC Pregnancy Childbirth. 2020;20:1–8.
44. Tesema GA, Worku MG. Individual-and community-level determinants of neonatal mortality in the emerging regions of Ethiopia: a multilevel mixed-effect analysis. BMC Pregnancy Childbirth. 2021;21:1–11.
45. Aynalem YA, Mekonen H, Getaneh K, Yirga T, Chanie ES, Bayih WA, et al. Determinants of neonatal mortality among preterm births in black Lion specialized hospital, addis Ababa, Ethiopia: a case–cohort study. BMJ Open. 2022;12(2):e043509.
46. Townsend R, Khalil A. Fetal growth restriction in twins. Best Pract Res Clin Obstet Gynecol. 2018;49:79–88.
47. Ogbo FA, Ezeh OK, Awosemo AO, Ifegwu IK, Tan L, Jessa E, et al. Determinants of trends in neonatal, post-neonatal, infant, child and under-five mortalities in Tanzania from 2004 to 2016. BMC Public Health. 2019;19:1–12.
48. Wanjoh SM, Muriithi DM. Modeling covariates of infant and child mortality in Kenya. 2020.
49. Yasmin S, Osrin D, Paul E, Costello A. Neonatal mortality of low-birth-weight infants in Bangladesh. Bull World Health Organ. 2001;79(7):608–14.
50. Tessema ZT, Tesema GA. Incidence of neonatal mortality and its predictors among live births in Ethiopia: Gompertz gamma shared frailty model. Ital J Pediatr. 2020;46:1–10.
51. Pellegrino J, Kanyangarara M, Agbinko-Djobalar B, Owusu PG, Sakyi KS, Baffoe P, et al. Occurrence of neonatal hypothermia and associated risk factors among low birth weight (LBW) infants in Accra, Ghana. J Global Health Rep. 2023;6:e2022066.
52. Kolola T, Gezahegn T, Addisie M. Health care seeking behavior for common childhood illnesses in Jeldu district, oromia regional State, Ethiopia. PLoS ONE. 2016;11(10):e0164534.
53. Gelaw YA, Biks GA, Alene KA. Effect of residence on mothers' health care seeking behavior for common childhood illness in Northwest Ethiopia: a community based comparative cross–sectional study. BMC Res Notes. 2014;7:705.
54. Beyene W, Jira C, Sudhakar M. Assessment of quality of health care in Jimma zone, Southwest Ethiopia. Ethiop J Health Sci. 2011;21(Suppl 1):49–58.
55. Nilima S, Sultana R, Ireen S. Neonatal, infant and under-five mortality: an application of Cox proportional hazard model to BDHS data. J Asiatic Soc Bangladesh Sci. 2018;44(1):7–14.
56. Agha S, Carton TW. Determinants of institutional delivery in rural Jhang. Pakistan Int J Equity Health. 2011;10:1–12.

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.