

Proximate low birth weight in three regions of Ethiopia with high stunting prevalence: Evidence from the 2016 Ethiopian demographic and health survey

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Abstract

Background

Globally, 15% to 20% of newborns are classified as low birth weight (LBW), with 13% of these cases occurring in sub-Saharan Africa. Infants born with LBW face a significantly higher risk of neonatal mortality. Those who survive frequently encounter lifelong health consequences, including stunting, impaired cognitive development, and a heightened predisposition to adult-onset chronic diseases. In Ethiopia, neonatal mortality attributable to LBW is substantial, representing a critical public health challenge that predisposes infants to severe short- and long-term complications. However, empirical evidence determining whether regions with a high prevalence of stunting simultaneously exhibit high rates of LBW remains limited. This study aimed to assess the prevalence of proximate low birth weight (PLBW) and its associated factors in the three Ethiopian regions experiencing the highest burden of stunting. While this is not a longitudinal cohort study assessing direct causality between LBW and stunting, the findings provide baseline epidemiological data to guide future research and prioritize stunting intervention strategies.

Methodology

This study utilized data from the 2016 Ethiopian Demographic and Health Survey (EDHS). The EDHS employed a stratified, two-stage cluster sampling methodology to generate a nationally representative sample, stratifying all administrative regions into urban and rural areas. Following rigorous data cleaning, the final analytic sample comprised 2,760 mother–child pairs. Statistical weighting and adjustments for the complex survey design (clustering and stratification) were applied to ensure accurate population estimates. A multivariable logistic regression model was utilized to evaluate the associations between PLBW and selected independent variables within the three high-stunting regions.

Results

Between 2011 and 2016, the highest absolute number of births among the targeted areas occurred in the Amhara region, though the proportional distribution of births across the three regions was relatively similar, ranging from 30.7% to 35.4%. The prevalence of PLBW in these three regions was 35.9% ($n = 991$). Within this cohort, 23.5% ($n = 649$) were perceived as very small (proxy for LBW), and 12.4% ($n = 342$) were perceived as smaller than average. In the final multivariable model, significant predictors of PLBW included rural residence (AOR = 2.20; 95% CI: 1.29–3.73), region of residence (Afar: AOR = 5.13, 95% CI: 3.97–6.64; Amhara: AOR = 2.49, 95% CI: 1.97–3.15), female infant sex (AOR = 1.46, 95% CI: 1.23–1.73), multiple birth at second parity (AOR = 3.54, 95% CI: 1.74–7.20), and younger maternal age (15–19 years: AOR = 2.25, 95% CI: 1.17–4.31).

Conclusions

The prevalence of PLBW in the three targeted regions is notably high, providing a plausible epidemiological context for their concurrent high burden of stunting. Rural residence, female infant sex,

multiple births, and early maternal age significantly increased the odds of PLBW. Implementing targeted public health policies to mitigate LBW risk factors in these specific regions is essential to ultimately reduce the high prevalence of childhood stunting.

Introduction

Birth weight is a foundational metric in assessing the efficacy of national and global child health initiatives and has been a primary target for public health intervention since May 2004 (1, 2). Globally, 15% to 20% of newborns are affected by low birth weight (LBW), with 13% of these cases localized in sub-Saharan Africa (2–4). Epidemiological evidence indicates that the mean birth weight of African neonates is significantly lower than that of neonates in developed nations. In East Africa, approximately 52% of neonatal mortality is directly attributable to LBW

(5). Furthermore, LBW infants who survive the high-risk neonatal period face enduring, life-long consequences, including an elevated risk of stunting, neurodevelopmental and cognitive deficits, and the premature development of adult-onset chronic diseases (6–9). In response to this global challenge, the World Health Assembly established a target to reduce LBW prevalence by 30% by 2025. Consequently, various intervention strategies comprising comprehensive prenatal, intrapartum, and postnatal care packages had been deployed (3, 10, 11). In Ethiopia, where neonatal mortality linked to LBW remains critically high, it is recognized as a profound determinant of both acute and chronic pediatric morbidities (6, 12, 13). While LBW is a well-documented driver of perinatal morbidity and mortality in developed nations, it remains underexplored in developing countries, complicating the design of cost-effective, localized interventions (4). A significant barrier to reliable LBW estimation in low-income settings is the high rate of home deliveries. For example, the 2011 Ethiopian Demographic and Health Survey (EDHS) indicated that only 5% of neonates were formally weighed at birth (14, 15). Despite these diagnostic challenges, the incidence of LBW serves as a crucial indicator for monitoring health goals established by the World Summit for Children (16). This study investigates whether Ethiopian regions characterized by a high prevalence of stunting concurrently exhibit high rates of LBW. Globally, stunting affects approximately 162 million children under the age of five

(17). Within Africa and specifically sub-Saharan Africa, estimated stunting rates are 35% and 42%, respectively (18). According to the 2017 World Health Organization (WHO) report, while the global prevalence of stunting has decreased proportionally since 2000, population growth has caused the absolute number of stunted children to rise from 50.4 million in 2000 to 58.5 million in 2016 (19). Ethiopia has achieved commendable progress in reducing childhood stunting from historically high levels in the 1990s (14, 20–22). The national prevalence decreased from 58% in 2000 to 44% in 2011, and further to 38% in 2016. Nevertheless, the burden remains unacceptably high and constitutes a major public health crisis (14, 21, 23). The 2016 EDHS highlighted marked regional disparities, identifying the Amhara region as the most severely affected by stunting (46%), followed by Benishangul-Gumuz (43%) and Afar (41%)

(21). Previous literature from Ethiopia suggests that maternal socio-demographic factors such as being unmarried, employment in manual labor or petty trade, severe food insecurity (monthly income (300ETB), and a lack of formal education are significant predictors of LBW (24). Additionally, a study from Malawi demonstrated that LBW infants possess a 55% increased risk of subsequent stunting (25). Given these intersections, this study aimed to assess the prevalence of proximate low birth weight (PLBW) derived from maternal recall of perceived birth size and its associated factors within the three Ethiopian regions most burdened by stunting. These findings will facilitate differential analyses, refine program designs, and optimize service delivery protocols related to maternal-fetal health (26).

Methods

Data source and study population

This secondary analysis utilized data from the 2016 Ethiopian Demographic and Health Survey (EDHS). Primary data collection occurred between January 18 and June 27, 2016. The 2016 EDHS is a comprehensive, nationally representative survey that gathers critical data on household characteristics, maternal and child health, mortality, nutrition, women's empowerment, and health-seeking behaviors to provide precise population health estimates (27). The survey cohort included women of reproductive age (15–49years), children under five years of age, and men of productive age (15–59years) (27, 28).

Sampling technique and study design

The 2016 EDHS employed a stratified, two-stage cluster sampling design. The 11 administrative regions of Ethiopia were explicitly stratified into urban and rural areas, yielding 21 distinct sampling strata. Independent samples of enumeration areas (EAs) were selected within each stratum. In the first stage, 645 EAs (clusters) were selected utilizing probability proportional to size (PPS) methodology, based on household counts from the 2007 Ethiopian Population and Housing Census. In the second stage, a comprehensive household listing operation was executed within the selected EAs to serve as the sampling frame. A fixed number of households were then selected via equal probability systematic sampling. Data collectors interviewed only the pre-selected households; no replacements were permitted during implementation to minimize selection bias. All under-five children who were usual residents or who slept in the selected households the night prior to the survey were eligible for the child module (28). Following the rigorous management of missing data, the final analytic sample for this study comprised 2,760 mother-child pairs, derived from the initial EDHS national cohort of 10,641 children.

Data collection tools and variables

The EDHS utilizes standardized instruments, adapted from the global DHS program, to accurately capture Ethiopia's specific demographic and epidemiological context. Data pertaining to child health and maternal practices were primarily extracted from the Woman's Questionnaire. The dependent variable for

this study was PLBW. The independent variables evaluated included maternal and child socio-demographics, community healthcare utilization, and maternal substance use (e.g., khat chewing), selected based on clinical relevance and dataset availability.

Due to the absence of clinical birth weight registries for the majority of home deliveries, "birth weight" was operationalized using maternal recall of the child's size at birth. Mothers categorized their neonates as *very large*, *large*, *average*, *small*, or *very small*. For analytical purposes, these responses were dichotomized into *average and above* (very large, large, and average) and *below average* (small and very small). In this study, the "below average" categorization serves as the proxy indicator for Proximate Low Birth Weight (PLBW).

Data analysis

Statistical analyses were performed using appropriate software. To account for the complex survey design, sampling weights were applied, and adjustments for clustering and stratification were incorporated to ensure nationally representative estimates. Descriptive statistics were used to summarize socio-demographic characteristics. Bi-variable logistic regression was conducted, and variables demonstrating a p-value (0.20) were advanced to a multivariable logistic regression model to identify independent predictors of PLBW. Statistical significance was defined as (P-value < 0.05).

Results

Socio-demographic characteristics

The final analysis included 2,760 mother-child pairs from the three high-stunting regions. The demographic profile revealed that 80.1% (n = 2,211) of the children resided in male-headed households. Educationally, a substantial majority of the mothers (75.5%, n = 2,085) reported having no formal education. Regarding religious affiliation, 54.0% (n = 1,490) identified as Muslim. Notably, only 1.1% (n = 30) of the deliveries in this cohort occurred via cesarean section, meaning 98.9% (n = 2,730) were vaginal deliveries (Table 1).

Table 1
Socio-demographic characteristic of respondents and their children in the three
stunting striking regions of Ethiopia, 2016

Variables	Categories	Frequency (n = 2760)	Percent
Head of household	Male	2211	80.1
	Female	549	19.9
Residence	Urban	221	8.0
	Rural	2539	92.0
Maternal age	15–19	106	3.8
	20–24	579	21.0
	25–29	824	29.9
	30–34	560	20.3
	35–39	418	15.1
	40–44	189	6.8
	45–49	84	3.0
Maternal education	No education	2085	75.5
	Primary	543	19.7
	Secondary	97	3.5
	Higher	35	1.3
Religion	Orthodox	1062	38.5
	Catholic	9	0.3
	Protestant	150	5.4
	Muslim	1490	54.0
	Traditional	45	1.6
	Other	4	0.1
Wealth index	Poorest	1321	47.9
	Poorer	467	16.9
	Middle	388	14.1
	Richer	352	12.8
	Richest	232	8.4

Variables	Categories	Frequency (n = 2760)	Percent
Readiness	Wanted then	2291	83.0
	Wanted later	328	11.9
	Wanted no more	141	5.1
Cigarette smoking	No	2720	98.6
	Yes	40	1.4
Chat chewing	No	2634	95.4
	Yes	126	4.6
Type of birth	Single birth	2689	97.4
	1st of multiple	34	1.2
	2nd of multiple	37	1.3
Sex of the child	Male	1426	51.7
	Female	1334	48.3
Place of delivery	Home	2216	80.3
	Health facility	544	19.7
Current marital status	Never in union	4	0.1
	Married	2668	96.7
	Living with partner	8	0.3
	Widowed	13	0.5
	Divorced	57	2.1
	Separated	10	0.4
Delivery by caesarean section	No	2730	98.9
	Yes	30	1.1

Prevalence of proximate low birth weight

Between 2011 and 2016, the highest absolute number of births among the three targeted regions occurred in Amhara, though the proportional distribution was relatively balanced: Benishangul-Gumuz accounted for 30.7% (n = 848), Afar for 33.9% (n = 935), and Amhara for 35.4% (n = 977) of the analyzed births. The prevalence of PLBW across these three stunting-burdened regions was 35.9% (n = 991). Breaking down the raw maternal categorizations prior to dichotomization: 41.1% (n = 1,134) of children

were reported as average size, 11.4% (n = 314) as very large, and 11.6% (n = 321) as larger than average. Conversely, 23.5% (n = 649) were perceived as very small (LBW), and 12.4% (n = 342) were perceived as smaller than average.

Factors associated with proximate LBW

Bi-variable logistic regression indicated preliminary associations between PLBW and wealth index, geographic region, pregnancy intention, type of birth, place of delivery, and maternal age.

Following multivariable logistic regression, several variables emerged as independent predictors. Rural residence significantly increased the odds of PLBW (AOR = 2.20; 95% CI: 1.29–3.73) compared to urban residence. Regional disparities were highly significant; compared to Benishangul-Gumuz, residing in the Afar region (AOR = 5.13; 95% CI: 3.97–6.64) or the Amhara region (AOR = 2.49; 95% CI: 1.97–3.15) drastically increased the odds of PLBW. Furthermore, female infants possessed 46% higher odds of PLBW compared to male infants (AOR = 1.46; 95% CI: 1.23–1.73). The strongest obstetrical predictor was multiple births during the second parity, which increased the odds of PLBW by a factor of 3.5 compared to singleton births (AOR = 3.54; 95% CI: 1.74–7.20). Finally, early maternal age (15–19 years) more than doubled the odds of PLBW compared to older mothers (45–49 years) (AOR = 2.25; 95% CI: 1.17–4.31) (Table 2).

Table 2

The association of proximate low birth weight and potential determinants in the three stunting striking regions of Ethiopia, 2016

Variable	Categories	Proximate low birth weight (n = 2760)		OR		95% CI		P-value
		No	Yes	COR	AOR	Lower	Upper	
Wealth index	Poorest	724 (54.8)	597 (45.2)	2.31*	0.96	0.57	1.62	0.87
	Poorer	336 (71.9)	131 (28.1)	1.09	0.89	0.52	1.52	0.66
	Medium	273 (70.4)	115 (29.6)	1.18	0.92	0.54	1.58	0.77
	Richer	265 (75.3)	87 (24.7)	0.92	0.73	0.43	1.26	0.26
	Richest	171 (73.7)	61 (26.3)	1	1			
Region	Afar	422 (45.1)	513 (54.9)	5.57*	5.13	3.97	6.64	0.001
	Amhara	651 (66.6)	326 (33.4)	2.29*	2.49	1.97	3.15	0.001
	Benishangul-Gumuz	696 (82.1)	152 (17.9)	1	1			
Residence	Rural	168 (76.0)	53 (24.0)	1.86	2.20	1.29	3.73	0.004
	Urban	1601 (63.1)	938 (36.9)	1	1			
Smoking	No	1742 (64.0)	978 (36.0)	1	1			
	Yes	27 (67.5)	13 (32.5)	0.86	1.24	0.60	2.59	0.56
Head of household	Male	1473 (66.6)	738 (33.4)	1	1			
	Female	296 (53.9)	253 (46.1)	1.71	1.21	0.97	1.51	0.09
Was child wanted	Wanted then	1459 (63.7)	832 (36.3)	1	1			
	Wanted latter	209 (63.7)	119 (36.3)	0.10	1.16	0.89	1.50	0.27

	Wanted no more	101 (71.6)	40 (28.4)	0.69*	1.13	0.75	1.69	0.57
Khat chewing	No	1680 (63.8)	954 (36.2)	1	1			
	Yes	89 (70.6)	37 (29.4)	0.73	0.89	0.59	1.35	0.59
Child sex	Male	958 (67.2)	468 (32.8)	1	1			
	Female	811 (60.8)	523 (39.2)	1.32	1.46	1.23	1.73	0.001
Child birth type	Single birth	1734 (64.5)	955 (35.5)	1	1			
	1st of multiple	20 (58.8)	14 (41.2)	1.27	1.74	0.83	3.64	0.14
	2nd of multiple	15 (40.5)	22 (59.5)	2.66*	3.54	1.74	7.20	0.001
Maternal education	No education	1276 (61.2)	809 (38.8)	1.38	0.71	0.31	1.63	0.42
	Primary	397 (73.1)	146 (26.9)	0.80	0.55	0.24	1.26	0.16
	Secondary	72 (74.2)	25 (25.8)	0.76	0.78	0.31	1.93	0.59
	Higher	24 (68.6)	11 (31.4)	1	1			

Delivery by CS	No	1749 (64.1)	981 (35.9)	1	1			
	Yes	20 (66.7)	10 (33.3)	0.89	1.18	0.50	2.81	0.70
Place of delivery	Home	1369 (61.8)	847 (38.2)	1.72*	1.20	0.93	1.56	0.17
	Health facility	400 (73.5)	144 (26.5)	1	1			
Maternal age	15–19	50 (47.2)	56 (52.8)	2.36*	2.25	1.17	4.31	0.02
	20–24	342 (59.1)	237 (40.9)	1.46	1.62	0.96	2.73	0.07
	25–29	547 (66.4)	277 (33.6)	1.07	1.16	0.70	1.93	0.57
	30–34	356 (63.6)	204 (36.4)	1.21	1.33	0.80	2.23	0.28
	35–39	289 (69.1)	129 (30.9)	0.94	1.10	0.65	1.86	0.73
	40–44	128 (67.7)	61 (32.3)	1.01	1.07	0.60	1.90	0.82
	45–49	57 (67.9)	27 (32.1)	1	1			
Current marital status	Not in union	3 (75.0)	1 (25.0)	1	1			-
	Married	1712 (64.2)	956 (35.8)	1.68	1.32	0.13	12.96	0.81
	Live with partner	7 (87.5)	1 (12.5)	0.43	0.53	0.02	11.92	0.69
	Widowed	7 (53.8)	6 (46.2)	2.57	1.30	0.10	16.7	0.84
	Divorced	33 (57.9)	24 (42.1)	2.18	1.23	0.12	12.77	0.86
	Separated	7 (70.0)	3 (30.0)	1.29	0.93	0.06	13.31	0.96
*=p < 0.05								

Discussion

This study sought to determine the prevalence of PLBW and identify its associated factors among children under five years of age residing in the three Ethiopian regions experiencing the highest burden of stunting. According to descriptive reports from the 2016 EDHS, the Amhara region is the most

severely affected by stunting nationally, followed closely by Benishangul-Gumz and Afar (21). While the intuitive validity and reliability of utilizing maternal perception of birth size as a proxy for clinical birth weight may be questioned, epidemiological research indicates that though maternal recall often slightly underestimates the true prevalence, it remains a robust and vital proxy measure (29). Furthermore, studies have demonstrated up to a 92% concordance rate between a mother's categorization of birth size and the clinically registered birth weight in medical records (29). Conversely, a localized study in Ethiopia argued that self-reported birth weight lacked accuracy compared to measured weight (30). However, that study was limited by substantial recall bias, noting that 85% of its respondents did not actually know their child's numerical birth weight (30). Crucially, over 58% of newborns globally, and more than 95% in Ethiopia, are not weighed at birth due to the prevalence of home deliveries (14, 31). Consequently, major global health initiatives including the DHS, Multiple Indicator Cluster Surveys (MICS), and Reproductive Health Surveys (RHS) rely on maternal assessment of physical size at birth as the standard proxy metric in developing nations (32, 33). Validation data from the 2016 EDHS confirmed that Ethiopian women accurately classified 68.9% of normal-weight and 85.6% of LBW infants (34). Thus, for policymakers operating in environments with poor clinical registries, maternal assessment serves as an indispensable epidemiological tool. Relying on this validated proxy, the present study found that the prevalence of PLBW in the three high-stunting regions was 35.9% (95% CI: 34.1–37.6). This is notably higher than rates reported in Oman (9%) (29), Iran (5.2%), and Kenya (12%) (35, 36), largely reflecting deep socioeconomic disparities between these nations. Furthermore, the prevalence observed in these three regions is drastically higher than both a previous Ethiopian systematic review (9.9%) (24), and the aggregated national LBW prevalence of 29.1% (37, 38). The congruence of excessively high PLBW rates and peak stunting rates in Amhara, Afar, and Benishangul-Gumz strongly supports the hypothesis that endemic LBW is a primary upstream driver of regional stunting.

Multivariable analysis revealed a pronounced rural penalty; rural residence increased the odds of PLBW by 120% (AOR = 2.20). This aligns with findings from Tanzania (39), India (40), and prior analyses of the 2011 EDHS (41). This consistent rural disadvantage is primarily driven by entrenched poverty, widespread food insecurity, and severely limited access to comprehensive antenatal care in rural settings. Regional variations within the study cohort were also stark. Children in Afar (AOR = 5.13) and Amhara (AOR = 2.49) faced much higher odds of PLBW than those in Benishangul-Gumz. The sustained, high prevalence of inter-generational stunting and poor maternal nutritional baselines in Amhara likely contribute to this disparity. In Afar, the population is predominantly pastoralist; the physical demands and nutritional instability associated with frequent migration disproportionately compromise fetal growth.

Maternal age was a significant predictor, with adolescent mothers (15–19years) exhibiting 2.25 times the odds of delivering a PLBW infant compared to women aged 45–49years. This mirrors earlier EDHS findings (41) and is physiologically rooted in the biological competition for nutrients between a still-growing adolescent mother and the developing fetus, compounded by lower health literacy and socioeconomic stability in younger mothers. Unlike previous analyses utilizing the entire national dataset (41), the household wealth index was not a statistically significant independent predictor in this sub-

regional cohort. This attenuation may be due to the homogenous, widespread poverty across these three highly burdened regions, limiting statistical variance. Furthermore, while a localized study in Bale, Ethiopia, linked maternal khat chewing to LBW (42), this association was not observed in our study, potentially reflecting differing frequencies or potencies of khat use across regions. Female infant sex was associated with a 46% increase in the odds of PLBW. Finally, multiple gestation, particularly during the second parity, drastically elevated the risk (AOR = 3.54). Multiple gestations inherently restrict intrauterine growth due to shared placental resources and physical spatial constraints, a biological reality exacerbated in resource-poor settings where maternal nutritional supplementation is inadequate.

The prevalence of Proximate Low Birth Weight in the three Ethiopian regions most heavily burdened by stunting is exceptionally high. This epidemiological overlap suggests that LBW is a critical precursor to the sustained stunting crisis in these areas. To effectively break the intergenerational cycle of stunting, the Ethiopian Ministry of Health and global partners would prioritize targeted, region-specific maternal nutrition and family planning interventions aimed at mitigating the identified risk factors for low birth weight.

The primary limitation of this study is its reliance on maternal recall to define birth weight, as self-reported visual assessment is an imperfect proxy for clinical measurement. However, in regions lacking comprehensive vital registration systems and high rates of home deliveries, PLBW remains the most viable and validated proxy indicator available for assessing population-level neonatal health and guiding public policy.

Abbreviations

AOR: Adjusted Odds Ratio, **CI:** Confidence Interval, **DHS:** Demographic and Health Survey, **EA:** Enumeration Area, **EDHS:** Ethiopian Demographic and Health Survey

LBW: Low Birth Weight, **PLBW:** Proximate Low Birth Weight, **PPS:** Probability Proportional to Size, **WHO:** World Health Organization

Declarations

Ethics approval and consent to participate

This study is a secondary analysis of the publicly available EDHS database. Access to the data was authorized by the DHS program following formal registration and request; therefore, direct ethical clearance for this specific analysis was waived. The primary data collection protocol for the 2016 EDHS was reviewed and approved by the Federal Democratic Republic of Ethiopia Ministry of Science and Technology and the Institutional Review Board (IRB) of ICF International.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

MWK, KDT, AMA, TWN, and STM conceptualized the study, extracted and processed the complex survey data, conducted the statistical analyses, critically interpreted the findings, and drafted the manuscript. All authors reviewed, revised, and approved the final version of this manuscript, agreeing to be accountable for all aspects of the work.

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Availability of data and materials

The dataset supporting the conclusions of this article is publicly available in the DHS program repository at <https://www.dhsprogram.com/>.

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