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Stillbirth trends and associated factors in eastern Ethiopia: A 10-year population-based surveillance study (2015–2024)

Merga Dheresa

mderesa@yahoo.com

Haramaya University

Abera Kenay Tura

Haramaya University

Abid Birhanu

Haramaya University

Kassiye Shiferaw

Haramaya University

Gamachis Daraje

Hararghe HDSS

Agnes Kiragga

African Population and Health Research Center

Damazo Kadengye

African Population and Health Research Center

Ivan Busuluwa

African Population and Health Research Center

Evans Omondi

African Population and Health Research Center

Taddese Gure

Haramaya University

Mary Kinney

University of Cape Town

Shimelash Bitew

Ethiopian Public Health Institute

Tigist Shumet

Ethiopian Public Health Institute

Tezera Berheto

Ethiopian Public Health Institute

Mesay Hailu Dangisso

Ethiopian Public Health Institute

Yadeta Dessie

Haramaya University

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Abstract

Introduction

: Stillbirth, defined as fetal death at or after 28 completed weeks of gestation, remains a public health and developmental problem, claiming about 2 million lives globally each year. Despite all the interventions, the national stillbirth rates in Ethiopia range from 9.2 to 20.6 per 1000 births depending on the data source or study population. In this study, we reported on the trends of stillbirth rate, and associated factors from January 2015 to December 2024.

Methods

The study was conducted in the Hararghe Health and Demographic Surveillance System (HDSS), an open dynamic population-based cohort in eastern Ethiopia. Data from pregnancy observation covering 66,231 birth outcomes from 48 kebeles of the HDSS were analyzed. Trends in stillbirth rate, defined as the number of stillbirths per 1000 total births, was computed with its corresponding 95% confidence interval (CI). Factors associated with stillbirth were identified using multilevel multivariable logistic regression with random intercepts at the household and kebele levels. Factors associated with stillbirth were presented using adjusted odds ratio (AOR) along with its 95% CI. Statistical significance was determined at p-values < 0.05.

Results

Of 66,231 births during the study period, 1,407 were stillbirths, corresponding with a stillbirth rate of 21.2 (95% CI: 20.15–22.38) per 1000 births. The stillbirth rate fell by 31.3%, from 17.11 per 1000 births in 2015 to 11.76 per 1000 in 2020, then rose sharply to 33.32 per 1000 in 2024, an absolute increase of 21.6 per 1000 births over the trough. Being born to rural women (AOR = 6.7; 95% CI: 4.4–10.1), mother who had no formal education (AOR = 1.4; 95% CI: 1.18–1.67), and mother who had no antenatal care (AOR = 1.5; 95% CI: 1.31–1.73), born at health facilities (AOR = 2.7; 95% CI: 2.41–3.17), born to mothers aged 20 to 34 years (AOR = 2.5; 95% CI: 2.05–3.17), and born to mothers older than 34 years (AOR = 6.3; 95% CI: 4.72–8.28) were associated with significantly higher odds of stillbirth. Conversely, stillbirth was less likely among multiparous women (AOR = 0.28, 95% CI: 0.24–0.34), grand multiparous women (AOR = 0.11; 95% CI: 0.09–0.14), and child born to medium household wealth index (AOR = 0.79, 95% CI: 0.68–0.93).

Conclusion

With fewer than five years remaining until 2030, the stillbirth rate in eastern Ethiopia remains almost twice the Sustainable Development Goal target of 12 per 1000 births. Strengthening maternal health

services such as antenatal care and improving quality of institutional delivery are essential if the stillbirth reduction target is to be met.

Background

Stillbirth is defined as fetal death at or after 28 completed weeks of gestation[1]. In 2023, an estimated 2.0 million babies were stillborn worldwide, resulting in a global stillbirth rate of 14 per 1,000 total births. Of these, 1 million occurred in Africa.[1–3]. Over the last two decades, stillbirth rate declined by 2.1% annually compared to a 2.4% and 3.0% reduction in neonatal and under-five mortality rate, respectively [3–6]. Sub-Saharan Africa had nearly one mission third-trimester stillbirths in 2023, the highest stillbirth rates in the world (22.2 per 1000 total births), and the slowest declines in the past two decades (-0.1% annual rate reduction compared to 2.1% globally)[1, 3]. Geographical disparities associated with inequity in access to health service and use, health literacy, and other developmental condition are estimated to be associated with stillbirth [5]. Moreover, poor living conditions, lack of access to education, poor prenatal and intrapartum care fuel perinatal mortality[7–9].

Stillbirth is associated with negative effect on parental mental health and increased direct and indirect costs to women, their partners, and families, health system, and the wider society[7, 10, 11]. Experience of stigma, social isolation, and disenfranchised grief are widespread among parents with stillbirth[7]. Mothers are often not allowed to mourn, and would be blamed, mistreated, and dishonored for stillbirth to the level leading to marital divorce. As such, stillbirth is such a secret and a hidden mourning for mothers and family, further contributing to under reporting [8].

Ethiopia ranks fourth globally for the total number of stillbirths with an estimated 125,700 stillbirths in 2023[3]. The country also has one of the highest stillbirth rates globally at 29.7 per 1000 total births [3, 12]. Despite being one of the countries achieving reducing under-five mortality as part of the millennium development goals[12], Ethiopia still has one of the highest stillbirth. While the government is working on expanding essential health service coverage[13], deploying community health workers[14], providing free of charge maternity and child health care [15], and implementing maternal and perinatal death surveillance and response [16] [17]. Poor quality of care, lack of medical equipment and supplies, and continued home births made stillbirth to be a living tragedy [12, 15]. Moreover, available data on stillbirth rates are inconsistent, reflecting differences in sources, populations, definitions, and methodologies, as well as limitations in routine reporting systems. Estimates vary considerably ranging from 11.4 per 1000 births according to the Ministry of health for 2021/22 [17], to 9.2 per 1000 births from a survey conducted in 2016[18], 13.7 per 1000 births from facility based data in 2019[19], and 20.6 per 1000 births according to WHO estimates for 2021 [20]. These variations highlight the challenges in accurately measuring the burden of stillbirths and the need for reliable, high-quality surveillance data to guide effective interventions. However, Ethiopia's ability to generate accurate stillbirth estimates is constrained by weaknesses in civil registration and surveillance systems. The civil registration and vital statistics (CRVS) captured only 10.3% of all deaths in 2021[21], while the maternal and perinatal death surveillance and response (MPDSR) system notified only 7% of the deaths [16]. In addition, sociocultural stigma and

taboos surrounding stillbirth may contribute to under reporting. Together, these challenges limit understanding of the true magnitude and causes of stillbirths in Ethiopia and hinder the development of targeted strategies to prevent avoidable stillbirths.

Making matters worse, countries with high burden of stillbirths, including Ethiopia, often lack other reliable data sources. Therefore, variation in the reported stillbirth rates and trends in stillbirth is not unexpected. In these settings where routine vital health registration systems are incomplete, key sources of stillbirth data include health management information system (HMIS) and DHIS2, and periodic demographic and health surveys. However, these sources may have limitations in completeness, continuity, and the ability to provide population-based estimates. Longitudinal surveillance system with clearly defined populations, denominators, and continuous data collection provide an important opportunity to generate more reliable estimates of stillbirth rates and monitor temporal changes. Therefore, this study assessed the prevalence, trends, and associated factors of stillbirth in the Hararghe Health and Demographic Surveillance System (HDSS), eastern Ethiopia, from January 2015 to December 2024.

Methods

Study design

This study was a retrospective population-based cohort study using longitudinal data from the Hararghe Health and Demographic Surveillance System (HDSS) in eastern Ethiopia, an open dynamic cohort that conducts regular surveillance in eastern Ethiopia. The HDSS collects vital events, including births, deaths, migration, and causes of death, as well as pregnancy outcomes, health seeking, and other relevant health indicators.

Study site

HDSS operates at three sites, namely Kersa (rural and semi urban site), Harar (urban site), and Haramaya (rural site). Kersa Health Demographic Surveillance System (HDSS) field site is located in Kersa district in East Hararghe zone, Ethiopia(Fig. 1**).** Kersa HDSS was established in 2007, starting with an initial census in 12 kebeles (small administrative unit in Ethiopia) to define the baseline denominator population; the initial census did not contain vital events (birth and death) [22]. Thereafter, the HDSS includes continuous longitudinal recordings of demographic data to monitor the population at regular intervals, observing relevant changes that occur in the designated population. HDSS field site was extended to Harari region in 2012 and operates among 6 kebeles. In 2015 each HDSS site (Kersa and Harar town) expanded their coverage and doubled the number of kebeles being monitored. Furthermore, in 2018 the Hararghe HDSS expanded to the Haramaya site (rural), which covers 12 kebeles. Currently, the HDSS covers 48 kebeles (24 kebeles from Kersa districts, and 12 kebeles from Harar town, and 12 kebeles from Haramaya site) with 65,000 households and a total of 325,000 individuals under

surveillance [12, 23–25]. We extracted data from the Kersa, Haramaya and Harar sites for 2015 to 2024 and from the Haramaya site for 2018 to 2024, the period during which each site was under surveillance.

Data collection and measurement

Data collection was conducted by well-trained local field workers and supervisors who resided within the study community, ensuring cultural alignment and native language fluency. Data were gathered electronically using tablet computers equipped with Open Data Kit (ODK) and integrated into an OpenHDS relational database to support longitudinal follow-up. Collected data were transmitted directly from the field to a central server via an internet connection. Office-based data supervisors and statisticians routinely performed automated and manual quality and consistency checks. Any identified discrepancies or errors were immediately communicated to field workers for verification and re-collection.

Pregnant women were prospectively monitored from identification through delivery. Key variables recorded included pregnancy intendedness, maternal morbidity during pregnancy, antenatal care utilization, place of delivery, and birth outcomes. Birth outcomes were classified as abortion, miscarriage, stillbirth, or live birth. In total, 66,231 birth outcomes were observed between January 2015 and December 2024 of which 1,407 were stillbirth.

Data processing and analysis

Outcome Variable

Stillbirth is the outcome variable for this study. Stillbirth was defined as fetal death at or after 28 completed weeks of gestation. The stillbirth rate was calculated as the number of stillbirths divided by the total number of births (live births plus stillbirths) in the same period, multiplied by 1000.

$$still\ birth = \left(\frac{\text{number of child stillborn after 28 weeks of gestation}}{\text{Number of all birth}} \right) * 1000.$$

Sociodemographic and reproductive health variables, namely residency (1 = urban, 2 = Rural); maternal education status (1 = formal education, 2 = no formal education); household wealth index (1 = poor, 2 = medium, 3 = rich); maternal age at first child birth (1 = < 20 years, 2 = 20 and above); parity (1 = primipara, 2 = multipara, 3 = grand multipara); antenatal care (1 = yes, 2 = no); place of delivery (1 = home, 2 = health facility); current age of mother (1 = Less than 20

2 = 20 to 34, and 3 = Above 34) were the independent variables.

All collected data were checked by the data manager and the HDSS coordinator for consistency and completion and analyzed using Stata 16. Descriptive variables were presented in percentage, and portrayed in table and graphs. We used multilevel multivariable logistic regression model to check the association between stillbirth and explanatory variables. In the bivariate analysis, we checked the

association between sociodemographic and reproductive health variables and stillbirth at $p < 0.25$. The association between explanatory variables and stillbirth was presented in adjusted odds ratio (AOR) along with 95% confidence interval (CI). Level of statistical significance was determined at p-value < 0.05.

Results

Sociodemographic characteristics of participants

In this study, we followed 66,231 pregnancies over 10 years (2015–2024). The majority of the women never attended formal education (45,618 (69.0%)), gave first birth before turning 20 years (46,955 (71.0%)), and were rural residents (55,189 (83.3%)) (Table 1).

Table 1
Sociodemographic characteristics of women who gave birth in Hararghe HDSS, Ethiopia from 2015–2024

Variable (n = 66231)	Response	n(%)
Residence	Urban	11,042 (16.7)
	Rural	55,189 (83.3)
Formal education	Yes	20,523 (31.0)
	No	45,618 (69.0)
Age at first child birth	Less 20	46,955 (71.0)
	20 and above	19,190 (29.0)
Parity	1	12,818 (19.4)
	2–4	32,313 (48.8)
	>=5	21,062 (31.8)
Wealth Index	Poor	22,598 (34.4)
	Medium	22,547 (34.3)
	Rich	20,553 (31.3)
Mother age (years)	Less than 20	7,382 (11.1)
	20 to 34	45,399 (68.5)
	Above 34	13,450 (20.3)

Maternal health service utilization

Overall, 46.9% of women received at least one antenatal care contact and 37.6% gave birth in a health institution (Fig. 2).

Prevalence and trends of stillbirth

During the study period, a total of 1,407 pregnancies ended in stillbirth, corresponding with an overall stillbirth rate of 21.24 (95% CI: 20.15–22.38) per 1000 births. The lowest annual rate, 11.76 (95% CI: 9.58–14.29) per 1000 births, was observed in 2020 and the highest, 33.32 (95% CI: 29.21–37.86) per 1000 births, in 2024 (Table 2).

While stillbirth rates remained comparatively low from 2015 to 2020 (ranging from 11.76 to 17.35 per 1,000 births), a sustained upward trajectory occurred from 2021 onward (Table 2). Between 2021 and 2024, the stillbirth rate increased from 25.85 per 1,000 births (95% CI: 22.65–29.37) to a peak of 33.32 per 1,000 births (95% CI: 29.21–37.86). This represents an absolute increase of 7.47 stillbirths per 1,000 births and a 28.90% relative increase over the three-year span (Table 2).

Table 2
Trends of stillbirth in Hararghe HDSS, eastern Ethiopia from 2015–2024 (n = 66231)

Year	All birth	Stillbirth	Stillbirth rate/1000 birth
2015	3975	68	17.11[13.28–21.69[]
2016	4859	68	13.99[10.87–17.74]
2017	5592	97	17.35[14.07–21.16]
2018	5822	75	12.88[10.13–16.15]
2019	4704	71	15.09[11.79–19.04]
2020	8587	101	11.76[9.58–14.29]
2021	9092	235	25.85[22.65–29.37]
2022	8444	212	25.11[21.84–28.72]
2023	8074	244	30.22[26.55–34.26]
2024	7082	236	33.32[29.21–37.86]
Total	**66231**	**1407**	**21.24[20.15–22.38]**

Stillbirths occurred more often among mothers residing in rural areas (1,276 (90.7%)), those with no formal education (1,028 (73.2%)), and women whose first birth occurred before 20 years of age (1,097 (78.1%)) (Table 3).

Table 3
Cross tabulation of stillbirth by each variable among women who gave birth in Hararghe HDSS from 2015–2024, Ethiopia

		Still birth			
		NO	Yes	Total	x^2 Test
Residence(n = 66,231)	urban	10,911(16.8%)	131 (9.3%)	11,042(16.7%)	< 0.001
	rural	53,913(83.2%)	1,276(90.7%)	55,189(83.3%)	
Formal education(n = 66,141)	yes	20,147(31.1%)	376 (26.8%)	20,523(31.0%)	< 0.001
	no	44,590(68.9%)	1,028(73.2%)	45,618(69.0%)	
Antenatal care(n = 66,231)	Yes	30,506(47.1%)	570 (40.5%)	31,076(46.9%)	< 0.001
	No	34,318(52.9%)	837 (59.5%)	35,155(53.1%)	
Place of delivery(n = 66,231)	Home	40,633(62.7%)	680 (48.3%)	41,313(62.4%)	< 0.001
	health facilities	24,191(37.3%)	727 (51.7%)	24,918(37.6%)	
Age at first child birth (n = 66145)	less 20	45,858(70.8%)	1,097(78.1%)	46,955(71.0%)	< 0.001
	20 and above	18,882(29.2%)	308 (21.9%)	19,190(29.0%)	
Parity (n = 66,191)	prime	12,298(19.0%)	520 (37.6%)	12,818(19.4%)	< 0.001
	Multi	31,726(49.0%)	587 (42.4%)	32,313(48.8%)	
	Grand multi parity	20,786(32.1%)	276 (20.0%)	21,062(31.8%)	
Wealth index(65,698)	poor	22,063(34.3%)	535 (38.2%)	22,598(34.4%)	0.003
	medium	22,118(34.4%)	429 (30.6%)	22,547(34.3%)	
	rich	20,116(31.3%)	437 (31.2%)	20,553(31.3%)	
Age(n = 66,231)	Less than 20	7,202 (11.1%)	180 (12.8%)	7,382 (11.1%)	0.021
	20 to 34	44,481(68.6%)	918 (65.2%)	45,399(68.5%)	
	Above 34	13,141(20.3%)	309 (22.0%)	13,450(20.3%)	

Factors associated with stillbirth

In the multi-level multivariable mixed effect regression model, socio-demographic, reproductive, and healthcare factors were independently associated with stillbirth after controlling for clustering at the kebele and household levels (Table 4). Rural women experienced over six-fold higher odds of stillbirth compared to urban residents (AOR = 6.73, 95% CI: 4.48–10.11). Women with no antenatal care (AOR = 1.51, 95% CI: 1.31–1.73), and those with no formal education (AOR = 1.40, 95% CI: 1.18–1.67) had significantly increased odds of stillbirth compared with their counterparts. Relative to mothers younger than 20 years at the time of birth, those aged 20 to 34 years (AOR = 2.55, 95% CI: 2.05–3.17) and those older than 34 years (AOR = 6.25, 95% CI: 4.72–8.28) had higher odds of stillbirth. Compared with women in poor households, those in medium-wealth households had lower odds of stillbirth (AOR = 0.79, 95% CI: 0.68–0.93), while the estimate for rich households was not statistically significant (AOR = 0.94, 95% CI: 0.80–1.10). Delaying first childbirth to age 20 or older was protective (AOR = 0.58, 95% CI: 0.49–0.68), as was higher parity (AOR = 0.11 for grand multiparity, 95% CI: 0.09–0.14). Facility-based delivery was associated with increased odds of stillbirth (AOR = 2.76, 95% CI: 2.41–3.17).

Table 4
Factors associated with stillbirth in Hararghe HDSS, eastern Ethiopia, 2015 to 2024 (n = 65,498)

Variable	Response	AOR	
Residence	Urban	1	
	rural	6.728[4.48, 10.11]	**
Formal education	Yes	1	
	no	1.402[1.18, 1.67]	**
Attending antenatal care	Yes	1	
	No	1.508[1.31, 1.73]	**
Place of birth	Home	1	
	health facilities	2.761[2.41, 3.17]	**
Age of mother at 1st child birth	Less than 20	1	
	20 and above	0.581[0.49, 0.68]	**
Parity	1	1	
	2–4	0.287[0.24, 0.34]	**
	>=5	0.110[0.09, 0.14]	**
Wealth index	Poor	1	
	Medium	0.791[0.68, 0.93]	**
	Rich	0.935[0.80, 1.10]	
Current maternal age	Less than 20	1	
	20 to 34	2.552[2.05, 3.17]	**
	Above 34	6.251[4.72, 8.28]	**

Discussion

In this study, we reported on the prevalence, trends and factors associated with stillbirth using a population based longitudinal cohort. We found that the stillbirth rate was almost twice the sustainable development goal targets. Moreover, there was an increase from 2021 to 2024, after a trend of decreasing pattern from 2015 to 2020. As we previously reported[12, 23] it is worrisome that stillbirth rate continued to stagnate or increase sometimes, making the journey towards a stillbirth rate of 12 per 1000 birth by 2030 uncertain[26]. Moreover, only 46.9% and 37.6% of all women in the cohort had at least one antenatal care contact and gave birth at a health facility, respectively, against the ENAP goal to

reach 90% global average for four or more antenatal care contacts and skilled birth attendance by 2030 [26], and national targets of 81% for four or more antenatal care contacts and 76% for institutional delivery by 2025[15]. Maternal health service utilization, which are proximal determinants of child and maternal survival, remained low. This needs a catchup strategy to maximize health service utilization in turn to reduce stillbirth rate. The key interventions known to reduce stillbirth were under-used in the Hararghe HDSS site.

Our overall stillbirth rate is in line with the WHO estimate of stillbirth rate in Ethiopia in 2021 (20.6 per 1000 births) [20], the 2016 global estimate of stillbirth (18.4) [27, 28], and the 2019 global estimate (21.7)[2, 28, 29]. However, our stillbirth rate in 2022 is more than twice the national figure of 11.4 per 1000 for the same year [17]. Given that our study draws on robust longitudinal community-based data that capture both home and facility births, unlike national data derived from routine facility-based reports, and that it is congruent with the WHO estimate, we consider our estimate to reflect the situation on the ground more closely. It is well documented that in many countries, including Ethiopia, reduction in the key maternal and newborn health indicators has stagnated[24].

The odds of stillbirth were 6.73 times higher among rural women compared to their urban counterparts. This marked geographic disparity aligns with global evidence demonstrating that spatial isolation, prolonged transport times, and decentralized health infrastructure compound perinatal risk in rural settings[30–32]. Mothers with no formal education had 40.2% higher odds of experiencing a stillbirth compared to those who had received formal education. Educated mothers are better equipped to understand obstetric danger signs and seek prompt medical intervention before complications become fatal to the fetus. Education enhances a woman's decision-making autonomy within the household, allowing her to prioritize financial resources for maternal health services, balanced nutrition, and emergency transportation[32–34].

Household economic status demonstrated a significant association with stillbirth risk at middle-wealth thresholds. Compared to mothers from poor households, those residing in medium-wealth households had 20.9% lower odds of experiencing a stillbirth. Although living in a rich household was also associated with a point reduction in odds (AOR = 0.94, 95% CI: 0.80–1.10), this finding did not achieve statistical significance. Moving from poverty to middle-income status may mitigate critical vulnerabilities. Medium-wealth households possess basic financial buffers to afford essential nutritional needs, routine maternity expenses, hygiene supplies, and timely out-of-pocket transportation to health facilities during labor onset[34, 35].

Maternal age at first childbirth was significantly associated with stillbirth risk. Compared to mothers whose initial delivery occurred during adolescence (< 20 years), those who delayed their first birth to age 20 or older had 41.9% lower odds of experiencing a stillbirth. Adolescent childbearing (< 20 years at first delivery) elevates stillbirth risk through combined biological, physiological, and social mechanisms. Current maternal age, a separate variable in the same model, showed the opposite gradient: compared with women younger than 20 years at the time of birth, women aged 20 to 34 years had more than

double the odds of stillbirth (AOR = 2.55, 95% CI: 2.05–3.17). This risk escalated sharply among women of advanced maternal age (> 34 years), who demonstrated over six times higher odds of stillbirth relative to the same reference group[36, 37].

As expected, the odds of stillbirth were 1.51 times higher among women who did not attend antenatal care, which is consistent with previous reports [18, 26, 29, 38–40]. There is evidence that poor-quality care accounts for 61% of neonatal deaths and half of maternal deaths[41, 42]. Facility-based delivery was associated with increased odds of stillbirth (AOR = 2.76), reflecting referral bias inherent to emergency obstetric presentations. Referred women often reach a health facility only after irreversible fetal compromise has occurred, so facility deliveries concentrate severe adverse outcomes. High-risk mothers or those experiencing acute emergency complications during home labor are preferentially referred or rushed to health facilities, artificially concentrating adverse outcomes in institutional settings[34, 43].

After adjusting for current maternal age, age at first birth, and other potential confounders, parity showed a strong inverse association with stillbirth. Compared with primiparous mothers, multiparous women had 71.3% lower odds and grand multiparous women 89.0% lower odds of stillbirth. Multiparous women are physically more mature and better able to carry a pregnancy to term than primiparous women. They also have prior experience of pregnancy and greater decision-making autonomy. Primiparous women therefore face a higher risk of adverse birth outcomes and need context-specific and age-specific interventions.

Parity, current maternal age, and age at first birth are strongly correlated with one another, so part of this apparent protective effect may reflect residual confounding between the three variables rather than an independent effect of parity[30, 34, 36, 43]

Limitations

This study has several limitations. Gestational age was based on maternal report rather than ultrasound dating, so misclassification between late miscarriage and stillbirth is possible. We could not distinguish antepartum from intrapartum stillbirth, which limits inference about the contribution of intrapartum care. The surveillance area expanded during the study period, so part of the observed trend may reflect a change in the composition of the population under surveillance rather than a change in underlying risk. Cause of death, birth weight, gestational age at delivery, and obstetric complications were not available, so residual confounding is likely. Finally, antenatal care and place of delivery were self-reported and subject to recall and social desirability bias.

Conclusion

Despite ongoing interventions by the Ministry of Health, stillbirth remains a major public health challenge in eastern Ethiopia. The stillbirth rate declined until 2020 but has risen steadily since, so it remains well above the target trajectory. These patterns reflect persistent gaps and inconsistencies in maternal health

service delivery and utilization. Furthermore, spatial disparities, health inequities, low wealth status, and limited maternal educational attainment were associated with higher odds of stillbirth. Mitigating this burden requires context-specific, tailored interventions that directly target structural inequities and local healthcare barriers.

Abbreviations

AOR Adjusted Odds Ratio

CI Confidence Interval

CRVS Civil Registration and Vital Statistics

DHIS, District Health Information System

ENAP Every newborn Action Plan

HDSS Health and Demographic surveillances System

HIM Health Management Information System

MPDSR Maternal and Perinatal Death Surveillance and Response

ODK Open Data Kit

WHO World Health Organization

Declarations

Ethics approval and consent to participate

This study was derived from Hararghe Health and demographic surveillance system, an integrated surveillance regularly collected diverse health outcome using standardized questioners. The Hararghe Health and demographic surveillance was approved by Haramaya University Institutional. Health Research Ethics Review Committee (IHRERC) under Ref. No. IHRERC/27/11/2014. **Informed consent was obtained from all study participants**.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Author Contribution

MD Lead the design research proposal, and entire data collection process. AK, AB, KS, lead manuscript writing. GD,AK, DK, IB, EO provide technical support during manuscript writing and analysis, TG, MK, SB, TS, TB, MH, YD engaged in manuscript writing and editing the manuscript. All authors approved the final manuscript

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Data Availability

The secondary longitudinal microdatasets analyzed during this study contain sensitive, confidential household and family tracking metrics managed by the Hararghe HDSS platform. Consequently, the raw dataset cannot be deposited into an open-access public repository due to participant privacy and strict institutional governance constraints. De-identified analytical files are available from the corresponding author upon reasonable request, subject to formal data access agreement and administrative approval from the Hararghe HDSS steering committee at Haramaya University. To facilitate peer review, the underlying data matrix will be securely provided directly to the journal reviewers upon request to satisfy any validation or reproducibility requirements. Email hararge.hdss.@haranaya.edu.et

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Figures

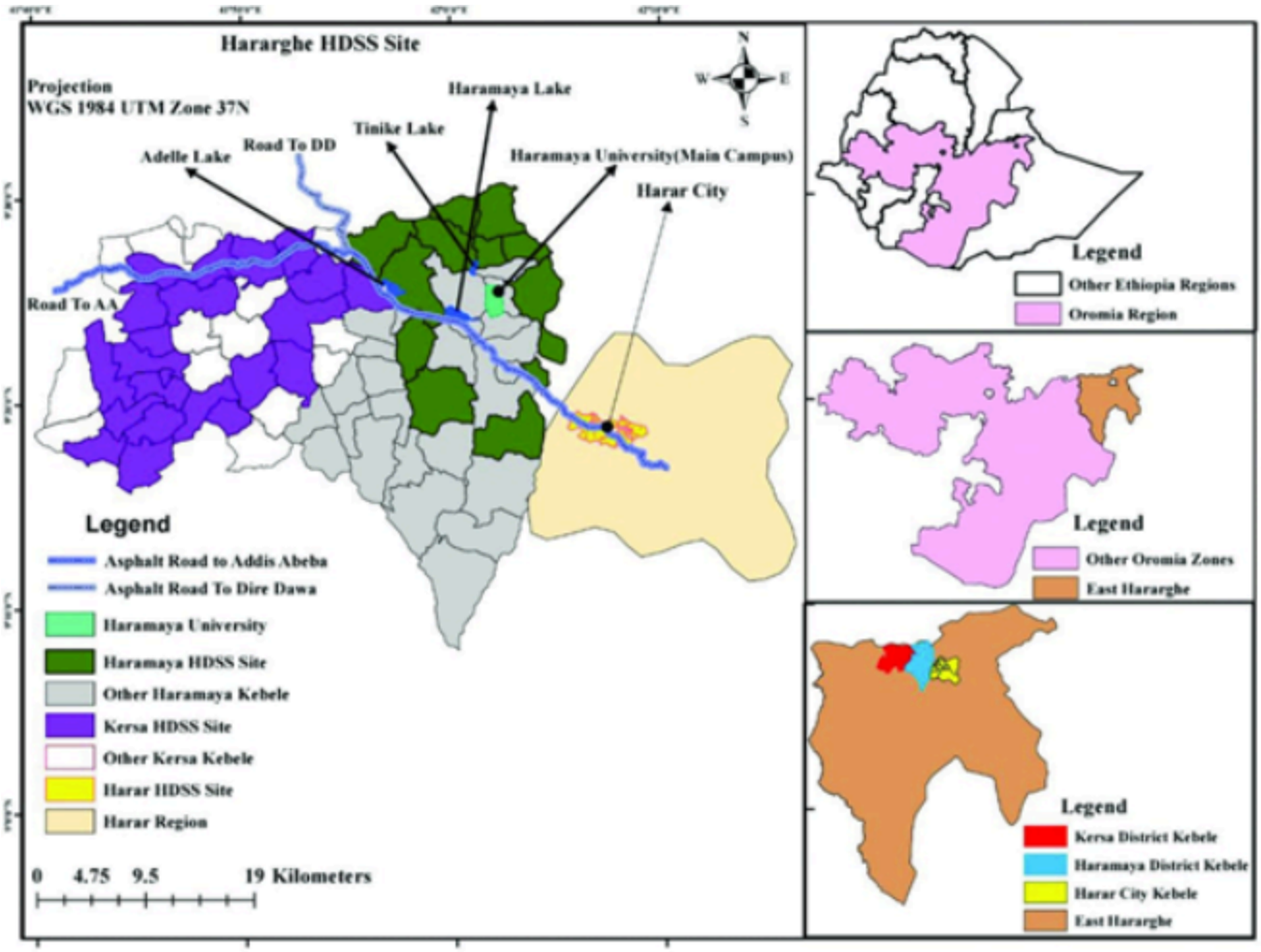


Figure 1

Hararghe HDSS site map, 2026, Ethiopia

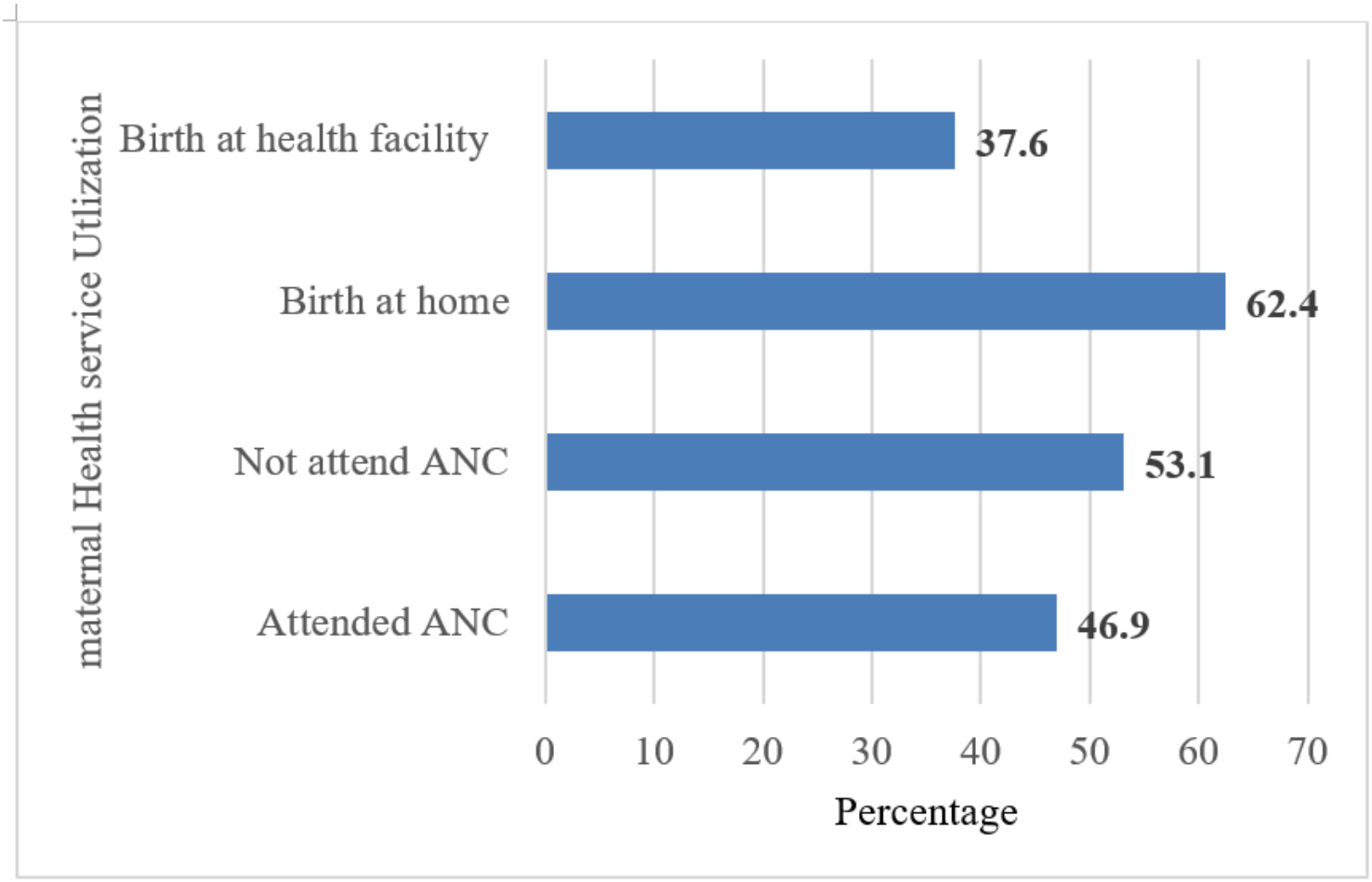


Figure 2

Maternal health service utilization among women who gave birth from 2015 to 2024 in Hararghe HDSS, eastern Ethiopia