

Optimum Maternal Healthcare Service Utilization and Infant Mortality in Ethiopia

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Abstract

Background: Ethiopia has one of the highest rates of infant mortality in the world. Utilization of maternal healthcare during pregnancy, at delivery, and after delivery is critical to reducing the risk of infant mortality. Studies in Ethiopia have shown how infant survival is affected by utilization of maternal healthcare services; however, no studies to date have investigated the effect of optimum utilization of maternal healthcare services based on the World Health Organization (WHO) guidelines on infant mortality. Therefore, this study examined the effect of optimum utilization of maternal healthcare services on infant mortality in Ethiopia.

Methods: We used nationally representative cross-sectional data from the Ethiopian Demographic and Health Survey (EDHS). Sampling weights were applied to adjust for the non-proportional allocation of the sample to the nine regions and two city administrations as well as the sample difference across urban and rural areas. We applied a multivariate logistic regression analysis to estimate the relationship between optimum maternal healthcare service utilization and infant mortality in Ethiopia.

Results: The findings from this study showed that optimum maternal healthcare service utilization had a significant association with infant mortality after adjusting for other socioeconomic characteristics. This implies that increased maternal healthcare service utilization decreases the rate of infant mortality in Ethiopia. The main finding from this study indicated that infant mortality was reduced by approximately 66% among mothers who had high utilization of maternal healthcare services compared to mothers who had not utilized maternal healthcare services (AOR=0.34; 95%CI: 0.16-0.75; p-value=0.007). Furthermore, infant mortality was reduced by approximately 46% among mothers who had low utilization of maternal healthcare services compared to mothers who had not utilized any maternal healthcare services (AOR=0.54; 95%CI: 0.31-0.97; p-value=0.040).

Conclusions: From this study, we concluded that optimum utilization of maternal healthcare services during pregnancy, at delivery and after delivery might reduce the rate of infant mortality in Ethiopia. The maternal healthcare service intervention packages in Ethiopia should involve a variety of care, spanning pregnancy, childbirth, and post-delivery, which should lead to the improvement of children's' survival in their first year of life.

Background

Infant mortality can be defined as the number of deaths of children under one year of age per 1000 live births in the same year [1]. It is an essential national health indicator; a high rate of infant mortality may be an indicator of poor healthcare infrastructure or poor health services [1, 2]. A reduction in infant mortality is one of the priorities of global health and international development agendas [3, 4]. It was a priority area during the Millennium Development Goals (MDGs), and it remains as a priority area in the Sustainable Development Goals (SDGs) for 2030 [5, 6]. Over the past two decades, the world has achieved remarkable progress in child survival [4]. Globally, the infant mortality rate has decreased by

50% between 1990 and 2017 [4]. According to a 2017 WHO report, infant mortality accounts for 75% of all under-five deaths [4]. The risk of a child dying before completing the first year of life was six times higher in the African region than that in the European region [4]. Infant deaths in developing countries are mainly due to preventable causes, such as pneumonia and diarrhoea [7]. The majority of infant deaths are due to avoidable causes and can be prevented using basic maternal healthcare service interventions, including the utilization of prenatal care services, skilled delivery, and postnatal care [8–10]. Despite the government's considerable effort to decrease the number of infant deaths, infant mortality in Ethiopia remains among the highest in the world [11, 12]. One of the key reasons for high infant mortality in Ethiopia is low utilization of modern healthcare services by many women in Ethiopia [13]. Previous cross-sectional studies based on Demographic and Health Surveys (DHS) data in Ethiopia have clearly indicated that utilization of maternal health services is very low in the country [14]. According to the Lancet Global Burden of Disease Study in 2015, to achieve the SDG targets regarding maternal and child mortality by 2030, it will require 91% coverage of one antenatal care visit, 78% of four antenatal care visits, 81% of in-facility delivery, and 87% of skilled birth attendance [15].

According to the 2016 Ethiopia Demographic and Health Survey, antenatal care utilization coverage, skilled delivery, and postnatal care utilization was 35%, 62%, 28%, and 17%, respectively [16]. Even though home delivery remains high, primarily in hard-to-reach rural areas, there have been improvements in antenatal care service utilization and institutional delivery in Ethiopia [16]. Furthermore, the Federal Ministry of Health in Ethiopia plans to increase the utilization coverage of antenatal care and skilled delivery to 95% and 90%, respectively, by the end of 2020 [17].

According to the Lancet Global Health, half of the world's population do not have access to modern health services [18]. However, according to the principles of universal health service coverage, everyone should have access to quality essential healthcare services [19]. The United Nations General Assembly has called on all countries to ensure universal health service coverage by 2030 [20]. Ethiopia is one of the countries with a high disease burden of reproductive health problem, maternal health problem, neonatal and child health problem and infectious diseases problem [21]. In addition, the country has low basic health services coverage and low health service utilization [22]. In 2015, the national health service coverage was 34.3%, ranging from 52.2% in the Addis Ababa city administration to 10% in the Afar region [23]. The universal health service coverage for neonatal and child health was 37.5% [23].

In this study, optimum maternal healthcare service utilization is the utilization of WHO recommended antenatal care visits, tetanus injection, skilled delivery, place of delivery, and postnatal check. The WHO recommends that a pregnant woman should receive a minimum of four antenatal care visits [24]. According to the WHO, the essential components of a basic prenatal care program are: identification of pregnancy, management of pregnancy-related complications, treatment of underlying illnesses, disease screening, preventive measures including tetanus toxoid immunization, de-worming, iron and folic acid, treatment of malaria in pregnancy, a birth and emergency preparedness plan, promotion of healthy behaviours at home, helping the pregnant woman and her partner prepare emotionally and physically for birth and care of their baby, and promotion of postnatal family planning/birth spacing [24]. The

attendance of a skilled health professional (doctor, nurse, or midwife) during delivery is also crucial to reduce child deaths. The WHO recommends that women who give birth either at home or in a health institution should stay at a health institution following childbirth [25]. The WHO recommends that regardless of the place of birth, women should not be discharged within 24 hours after delivery [25].

Poor utilization of maternal healthcare services has a significant impact on the outcomes of child health [26]. Utilization of recommended antenatal care during pregnancy improves maternal and child health outcomes [27]. Evidence from DHS data from 17 sub-Saharan African countries showed that having prenatal care provided by a skilled practitioner reduced the odds of neonatal mortality by 30% [28]. A finding from a systematic review done in sub-Saharan African countries also revealed that women receiving at least one antenatal care visit during pregnancy decreased neonatal mortality by 39% [29]. Research has indicated that utilization of prenatal healthcare significantly reduces maternal and child mortality [30, 31]. Prenatal care during pregnancy is critical for the foetus and mother's health [32]. Prenatal care increases the chance of skilled birth attendance, which can improve the likelihood of child survival in the first year of life [32]. A cross-sectional study in West Africa showed that having any prenatal care was associated with lower infant mortality [33]. A nationally representative health survey in Zimbabwe also indicated that poor quality prenatal care contributes to neonatal and infant mortality; a one-unit increase in the quality of prenatal care decreased infant mortality by nearly 31% [34]. Another finding from a systematic review in Ethiopia showed that antenatal care utilization reduces neonatal mortality by 34% [35, 36]. Having optimum antenatal care follow-up for either chronic diseases or acute diseases during pregnancy can prevent further complications occurring for mothers and infants and reduce the prevalence of low birth weight by improving the nutritional status of a mother during pregnancy [37–39]. Tetanus immunization during pregnancy was associated with a reduction of infant mortality; providing women with two doses of tetanus toxoid was estimated to reduce mortality from neonatal tetanus by 94% [40]. The deaths of early infants caused by neonatal tetanus can be decreased by half through a combination of maternal tetanus immunization and clean delivery practice [41].

Previous finding found that there was an association between deaths of children less than one year old and skilled birth and health facilities delivery [42]. A systematic review from developing countries has shown that delivery at health facilities reduces the risk of under one child mortality by 29% [42]. Another facility-based case control study in India indicated that postnatal check-up after institutional delivery was significantly associated with reduced deaths of children in the early years [43]. A systematic review conducted in developing countries found that frequent postnatal visits reduced neonatal deaths; it was also encouraged women to exclusively breastfeed [44].

From the above evidence, infant mortality is significantly associated with the number of antenatal care visits, tetanus injection during pregnancy, place of delivery, and skilled birth attendance in the midst of other variables. Maternal healthcare service utilization during pregnancy and delivery decreases the risk of infant mortality. However, examining the independent relationship between antenatal care and infant mortality, postnatal care and infant mortality, tetanus toxin (TT) and infant mortality might not give adequate evidence for policy formulation. For example, if a pregnant woman has attended the

recommended antenatal care, but she was not assisted by a skilled health professional and did not follow up postnatal care, the survival of her child may be at higher risk. The interrelated nature of these maternal healthcare service indicators needs to be addressed in an integrated way to enhance the survival chance of infants. Therefore, five indices of maternal healthcare services were combined by scoring each indicator to produce a combined score. Combining the indices of maternal healthcare service utilization can help to understand the effect of optimum maternal healthcare service utilization on infant mortality in Ethiopia. We expect that the rate of infant mortality will be lower among women who were high users of maternal healthcare services compared with women who did not use maternal healthcare services.

Methods

Study area and setting

We used data from the fourth Ethiopian Demographic and Health Survey (EDHS), which was conducted in 2016. The 2016 EDHS provided valuable information on trends of key demographic and health indicators over time. The EDHS was conducted by the Central Statistics Agency (CSA) in collaboration with the Federal Ministry of Health and the Ethiopian Public Health Institute with technical assistance from ICF International and funding from the United States Agency for International Development (USAID). The study was conducted in all nine geographical regions and two administrative cities of Ethiopia [16].

Study design and sampling

The 2016 EDHS is a nationally representative cross-sectional household survey. The study participants were selected through a stratified two-stage cluster sampling technique. The sampling frame used for the 2016 EDHS was the Ethiopia Population and Housing Census (PHC), which was conducted in 2007 by the Ethiopia CSA. The sampling frame contains information about the enumeration area (EA) location, type of residence (urban or rural), and estimated number of residential households. The 2016 EDHS sample was stratified and selected in two stages [16]. In the first stage, a total of 645 EAs (202 in urban areas and 443 in rural areas) were selected with probability proportional to EA size (based on the 2007 PHC). In the second stage, a fixed number of 28 households per cluster was selected with an equal probability systematic. All women aged 15–49 years who were either permanent residents of the selected households or visitors who stayed in the household the night before the survey were eligible to be interviewed [16]. In the original sample, 15,683 women of childbearing age who had live births within five years prior to the survey were interviewed [16]. However, for this study, we focused on 7,193 most recent births; this study was also limited to women who had provided complete information on infant mortality, antenatal care visits, tetanus injections, place of delivery, and skilled birth attendance during pregnancy.

Study variables

Outcome variable

The outcome variable for this study was infant death (Yes, No).

Exposure variables (Table 1)

Data analysis

Descriptive statistics were presented as means and standard deviations for continuous measures, frequencies and percentages for categorical variables. The data were weighted before use to ensure representativeness since a cluster design approach was used. Data were cleaned for completeness and descriptive statistics are presented.

At the first stage of the analysis, a Chi-square test was used to establish an association between 'Infant mortality' and the independent variables mentioned above. In addition, a Chi-square model was used to establish an association between 'Maternal healthcare service utilization' and other independent variables to identify confounding variables. Thereafter, statistically significant variables ($\alpha = 5\%$) associated with infant mortality and associated with maternal healthcare service utilization were entered into a multivariable model to account for confounding. Finally, multivariate logistic regression analysis was performed to estimate the adjusted odds ratios. The association between maternal healthcare service utilization and infant mortality were expressed using adjusted odds ratios (AOR) with 95% confidence intervals (CI). A p-value of < 0.05 was used to determine the cut-off for statistical significance.

Ethical considerations

The EDHS sought informed consent and was approved by the study subjects during data collection. The confidentiality of the respondents was also assured by the EDHS. Approval was obtained from the Human Research Ethics Committee of the University of Newcastle. A letter of approval was also obtained from MEASURE EDHS to use the dataset. The information obtained from the dataset was not disclosed to any third persons.

Results

The rate of infant mortality was higher among male children than female children; the rate of infant mortality was 23.8 and 8.6 in males and females, respectively. Of all infant deaths, 73.6% were males. The rate of infant mortality in rural areas was 29.5 per 1000. The rate of infant mortality was higher in rural areas than in urban areas (2.9 per 1000). The rate of infant mortality decreased when maternal education increased. The rate of infant mortality was higher among infants born with a small birth size compared to infants born with an average birth size. The rate of infant mortality was higher across women who had not utilized maternal healthcare services compared with women who had high maternal healthcare service utilization (Table 2).

Table 2
 Frequency and percentage distribution of infant mortality by study population characteristics
 (n = 7,590)

Variables	Infant mortality		Total births	IMR per 1000
	Yes (n = 246) N (%)	No (n = 7344) N (%)	n = 7590 N (%)	live birth
Infant sex				
Male	181 (73.6)	3,759 (51.2)	3,940 (51.9)	23.8
Female	65 (24.4)	3,585 (48.8)	3,650 (48.1)	8.6
Type of birth				
Singleton	213 (86.6)	7,257 (98.8)	7,470 (98.4)	28.1
Multiple	33 (13.4)	87 (1.2)	120 (1.6)	4.3
Reported birth weight				
Above average	86 (35)	2,313 (31.5)	2,399 (31.6)	11.3
Average	78 (31.7)	3,069 (41.8)	3,147 (41.5)	10.3
Below average	82 (33.3)	1,962 (26.7)	2,044 (26.9)	10.8
Preceding birth interval				
First birth	38 (15.4)	1,408 (19.2)	1,446 (19.1)	5
< 24 months	56 (22.8)	1,020 (13.9)	1,076 (14.2)	7.4
24–59 months	118 (48)	3,857 (52.5)	3,975 (52.4)	15.5
>=60 months	34 (13.8)	1,057 (14.4)	1,091 (14.4)	4.5
Maternal age (years)				
15–24	58 (23.6)	1,747 (23.8)	1,805 (23.8)	7.6
25–34	110 (44.7)	3,716 (50.6)	3,826 (50.4)	14.5
35–49	78 (31.7)	1,881 (25.6)	1,959 (25.8)	10.3
Maternal education				
No education	161 (65.4)	4,630 (63.0)	4,791 (63)	21.2
Primary education	67 (27.2)	2,082 (28.3)	2,1491 (28.3)	8.8
Secondary education	18 (7.3)	632 (8.6)	650 (8.7)	2.4
Age at first birth (years)				

Variables	Infant mortality	Total births		IMR per 1000
Less than 20	23 (9.3)	666 (9.1)	689 (9.1)	3
20–34	160 (65.1)	5,278 (71.9)	5438 (71.6)	21.1
35–49	63 (25.6)	1,400 (19.1)	1463 (19.3)	8.3
Total children ever born				
1	30 (12.2)	1,405 (19.1)	1435 (18.9)	4
2–3	83 (33.7)	2,198 (29.9)	2,281 (30.0)	10.9
4–5	36 (14.6)	1,715 (23.4)	1,751 (23.1)	4.7
5+	97 (39.4)	2,025 (27.6)	2,122 (38.0)	12.8
Wealth index				
Poor	107 (43.5)	3,199 (43.6)	3,306 (43.6)	14.1
Middle	46 (18.7)	1,542 (21.0)	1,588 (20.9)	6.1
Rich	93 (37.8)	2,603 (35.4)	2,696 (35.5)	12.3
Religion				
Christian	117 (47.6)	4,489 (61.1)	4,605 (60.1)	15.4
Muslim	129 (52.4)	2,695 (36.7)	2,824 (37.2)	17
Traditional	0 (0)	97 (1.3)	97 (1.3)	0
Other	0 (0)	64 (0.9)	64 (0.84)	0
Number of living children				
One or less	82 (33.3)	1,503 (20.5)	1,585 (20.9)	10.8
2–3	62 (25.2)	2,405 (32.7)	2,467 (32.5)	8.2
4–5	46 (18.7)	1,837 (25)	1,883 (24.8)	6.1
>=6	56 (22.8)	1,599 (21.8)	1,655 (21.8)	7.4
Number of pregnancy losses (miscarriage, abortion or stillbirth) and child deaths				
None	83 (33.7)	5,229 (71.2)	5,312 (70.0)	10.9
One	93 (37.8)	1,435 (19.5)	1,528 (20.1)	12.3
Two	49 (19.9)	452 (6.2)	501 (6.6)	6.5
Three or more	21 (8.5)	228 (3.1)	249 (3.3)	2.8
Head of household				

Variables	Infant mortality	Total births		IMR per 1000
Male	215 (87.4)	6,259 (85.2)	6,474 (85.3)	28.3
Female	31 (12.6)	1,085 (14.8)	1,116 (14.7)	4.1
Region				
Tigray	12 (4.9)	525 (7.1)	537 (7.1)	1.6
Afar	3 (1.2)	68 (0.9)	71 (1)	0.4
Amhara	49 (19.9)	1,584 (21.6)	1633(21.5)	6.5
Oromia	118 (48.0)	3,011 (41)	3129 (41.2)	15.5
Somali	13 (5.3)	256 (3.5)	269 (3.5)	1.7
Benishangul	2 (0.8)	79 (1.1)	81 (1.1)	0.3
SNNPR	43(17.5)	1,557 (21.2)	1600 (21.1)	5.7
Gambela	1 (0.4)	20 (0.3)	21 (0.3)	0.1
Harari	1 (0.4)	17 (0.2)	18 (0.2)	0.1
Addis Adaba	3 (1.2)	195 (2.7)	198 (2.6)	0.4
Dire Dawa	1 (0.4)	32 (0.4)	33 (0.4)	0.1
Residence				
Urban	22 (8.9)	947 (12.9)	969 (12.8)	2.9
Rural	224 (91.1)	6,397 (87.1)	6621 (87.2)	29.5
Maternal decision-making autonomy				
No	112 (45.5)	2,563 (34.9)	2,675 (35.2)	14.8
Yes	134 (54.5)	4,781 (65.1)	4,915 (64.8)	17.7
Maternal employment				
Employed	122 (49.6)	3,957 (53.9)	4,079 (53.7)	16.1
Unemployed	124 (50.43.5)	3,388 (46.1)	3,512 (46.3)	16.3
Access to media				
No access	138 (56.1)	4,832 (65.8)	4,970 (65.5)	18.2
Less than once a week	55 (22.4)	1,080 (14.7)	1,135 (15.0)	7.2
At least once a week	54 (22)	1,432 (19.5)	1,486 (19.5)	7.1
MHCI				

Variables	Infant mortality	Total births		IMR per 1000
None	93 (38.8)	1931 (26.3)	2,024 (26.7)	12.3
Low	89 (36.2)	3078 (41.9)	3167 (41.7)	11.7
Medium	36 (14.6)	996 (13.6)	1,032 (13.6)	4.7
High	28 (11.4)	1339 (18.2)	1367 (18.0)	3.7
Contextual region				
Agrarian	225 (91.5)	6793 (92.5)	7018 (92.5)	29.6
Pastoralist	16 (6.5)	24 (4.4)	340 (4.5)	2.1
City dweller	5 (2)	227 (3.1)	232 (3)	0.7

From the multivariable logistic regression model, infant mortality was significantly associated with multiple pregnancies, birth interval, number of pregnancy losses (miscarriage, abortion or stillbirth) and child deaths, and maternal healthcare utilization. Women with multiple pregnancies had 11.7 higher odds of infant mortality compared with women who had a single pregnancy (AOR = 11.7; 95%CI: 5.45–25.19; p-value < 0.001). Preceding birth interval was also significantly associated with infant mortality. An infant with a short birth interval had higher odds of death compared with an infant born with an interval of 24 to 59 months (AOR = 1.6; 95%CI: 1.11–2.6; p-value = 0.005). Other controlling variables associated with infant mortality included pregnancy loss and previous history of child deaths. As the number of pregnancy losses and previous child deaths increased, infant mortality also increased; infants born to women with more than three pregnancy-related events were 7.2 times more likely to die compared with infants born to mothers who had no pregnancy losses or child deaths (AOR:7.16: 95%CI:2.38–21.50; p-value < 0.001). Women's access to modern healthcare services was significantly associated with deaths of children under one year. Infants of women who had high access to modern healthcare services had lower odds of death compared with infants of women who had no access to modern healthcare services (AOR = 0.34:95%CI:0.16–0.75; p-value = 0.007) (Table 3).

Table 3
Multivariate logistic regression association of maternal healthcare service utilization with infant mortality in Ethiopia

Variables	AOR (95% CI)	p-value
Contextual region		
Agrarian	1 (reference)	
Pastoralist	1.23 (0.77–1.96)	0.390
City dweller	0.95 (0.39–2.33)	0.910
Multiple pregnancies		
Yes	11.71(5.45–25.19)*	< 0.001*
No	1 (reference)	
Birth interval		
First birth	1.40 (0.67–2.94)	0.370
< 24 months	1.60 (1.11–2.60)*	0.005*
24–59 months	1 (reference)	
>=60 months	1.30 (0.68–2.44)	0.430
Maternal education		
No education	1 (reference)	
Primary education	1.21 (0.72–2.042)	0.460
Secondary or higher	1.54 (0.46–5.20)	0.490
Maternal age (years)		
15–24	reference	
25–34	0.64 (0.35–1.16)	0.140
35–49	0.54 (0.25–1.16)	0.120
Wealth index		
Poor	reference	
Middle	0.92 (0.47–1.82)	0.820
Rich	1.39 (0.83–2.31)	0.210
Residence		
Urban	reference	

Variables	AOR (95% CI)	p-value
Rural	1.20 (0.49–2.93)	0.690
Maternal decision-making autonomy		
No	reference	
Yes	0.70 (0.45–1.07)	0.100
Number of pregnancy losses (miscarriage, abortion or stillbirth) and child deaths		
None	1 (reference)	
One	4.65(2.86–7.60)*	< 0.001*
Two	7.82 (4.18–14.66)*	< 0.001*
Three or more	7.16 (2.38–21.50)*	< 0.001*
MHCI		
None	1 (reference)	
Low	0.54 (0.31–0.97)*	0.040*
Medium	0.78 (0.41–1.50)	0.460
High	0.34 (0.16–0.75)*	0.007*

Discussion

The rate of infant mortality was lower among women who experienced high utilization of maternal healthcare services compared with women who had no experience of maternal healthcare service utilization. The rate of infant mortality among women who reported high maternal healthcare utilization was 3.7 per 1000 compared to 12.3 per 1000 among women who reported no maternal healthcare utilization. The rate of infant deaths found in this study was consistent with a previous study conducted in Nigeria, which reported that the mean maternal healthcare service utilization was higher among mothers who reported low infant deaths compared to mothers who reported high infant deaths [47].

The results from the multivariable analysis in this study showed that the combined five indicators of maternal healthcare service utilization (antenatal attendance, tetanus injection, place of delivery, skilled birth attendance, and postnatal check) was significantly associated with infant deaths. The findings from this study showed that optimum maternal healthcare service utilization had a significant association with infant mortality. As maternal healthcare service utilization increased, infant mortality decreased. High maternal healthcare service utilization prevented infant mortality by approximately 66% compared to no maternal healthcare service utilization. In addition, low maternal healthcare service utilization prevented infant mortality by 46% compared to no maternal healthcare service utilization at all. Previous studies have reported that high maternal healthcare service utilization during pregnancy is essential for mothers'

health and the survival of their infants [28, 48]. Optimum maternal healthcare service utilization during and after pregnancy is critical for the survival of an infant; early and regular maternal healthcare service utilization is also essential for the health of both the mother and the infant [49]. Optimum maternal healthcare service utilization such as having the recommended number of antenatal care visits and receiving appropriate and timely care ensure the survival of child [50]. While many previous studies have shown how infant mortality is affected by independent maternal healthcare service utilization, examining the independent relationship might not give adequate evidence on how maternal healthcare utilization affects infant mortality [32, 43]. An infant of a woman who attended antenatal care but was not assisted by a skilled health professional during delivery may have reduced odds of survival. The evidence on combined indices of maternal healthcare service utilization may provide clearer insight to policy makers in Ethiopia. The findings from this study may also contribute to the current literature on how combined maternal healthcare services could affect infant mortality.

Access to and utilization of healthcare facilities during pregnancy can increase the likelihood of a woman using skilled birth attendance during delivery and postnatal check-up, which are essential to the survival of the infant. This finding is consistent with the literature on the association between maternal healthcare service utilization and infant survival. Low maternal healthcare service utilization in Ethiopia is one of the highest in the world, which is also one of the contributing factors to the high infant mortality in the country [51]. In a birth cohort and matched case-control study in Ethiopia, it was reported that utilizing antenatal care reduces infant mortality [52, 53]. This could be because mothers who attend antenatal care during pregnancy can properly receive services such as nutritional counselling, nutritional screening and more [54]. Maternal healthcare service utilization may help to inform and educate mothers about maternal and infant health. It can provide an opportunity to screen for warning signs of pregnancy complications and treatment of infections [35]. Besides, maternal healthcare service utilization enables health workers to teach women about complications during pregnancy, labour, and delivery [55]. Furthermore, antenatal care utilization provides an opportunity to inform women about danger signs and the importance of modern healthcare utilization [55].

A previous study conducted on the combined effect of maternal healthcare service utilization on infant mortality in Nigeria showed that infant deaths were higher among women with no or low maternal healthcare service utilization compared with high and complete maternal healthcare service utilization [47]. A national study in Kenya showed that a lack of skilled antenatal care and insufficient antenatal care visits increases neonatal mortality. In the same study, researchers also indicated that a single tetanus toxoid vaccination during pregnancy could prevent about 10% of neonatal deaths [56].

Prenatal healthcare service utilization during pregnancy is critical for the foetus and the mother's health. Prenatal healthcare service utilization also increases the chance of using a skilled birth attendant, which improves the likelihood of child survival in the first year of life [32]. Antenatal care provides an opportunity to identify risk factors, prevent complications, and improve the birth preparedness of pregnant women in order to reduce infant mortality [57]. In a national study in Zimbabwe, it was indicated that mothers' health-seeking behaviours, such as giving birth in health facilities, receiving antenatal care

from skilled providers and being assisted by skilled birth attendants during delivery, lowered the risk of child deaths at an early age. The results indicated that a one-unit increase in the quality of prenatal care lowered infant mortality by approximately 31% [58]. Studies conducted in poor resource countries have indicated that utilization of maternal healthcare services, such as skilled birth attendance and delivery at healthcare facilities, can reduce maternal and child mortality [30, 31]. A high coverage of healthcare service utilization could reduce the death of a child. An evidence-based cost-effective intervention showed that a 90% coverage of facility-based care could reduce early child mortality by 23–50% [43]. Another study in West Africa showed that having any prenatal care was associated with lower infant mortality [33].

Maternal healthcare service utilization may influence infant outcomes in different ways. For example, prenatal care may make a difference in pregnancy outcomes [48, 59]. Inadequate or lack of prenatal care is a risk factor for low birth weight and other poor pregnancy outcomes. Women who had no access to maternal healthcare services were more likely to give birth to a low weight infant [48, 59]. Access to good healthcare during pregnancy is essential for a woman's health and for the development of her unborn child. Besides, accessing a modern health system during pregnancy increases the chance of using a skilled birth attendant during delivery, and this may contribute to the good health of a child in their first year of life [32, 49]. Women from low-income countries, such as countries in sub-Saharan Africa and South Asia, are less likely to receive adequate maternal healthcare. For example, these low-income regions have low numbers of skilled health workers [60]. In high-income and middle-income countries, more than 90% of all births were assisted by a trained midwife, doctor or nurse. However, in several low-income countries, only fewer than half of all births were assisted by such skilled health personnel [60].

Finally, this study had the following strengths and limitations. For this study we used a nationally representative dataset which covered all regions in Ethiopia in an effort to provide nationwide evidence to policy makers. The EDHS data were also well designed. However recall bias is possible as study participants were asked to remember events five years before the survey. There may also be the possibility of error due to the self-reported nature of data collection.

Conclusions

Despite progress made in maternal healthcare service utilization in Ethiopia, the country still has unsatisfactory levels of optimum utilization of maternal healthcare services, such as the low use of the recommended number of antenatal care visits. From this study, we can conclude that as maternal healthcare service utilization increases, the probability of infant deaths in Ethiopia decreases. If a woman uses optimum maternal healthcare services during pregnancy and during delivery, the infant mortality rate may reduce in Ethiopia. Essential maternal healthcare service intervention packages in Ethiopia should involve a variety of care that spans pregnancy, childbirth, and post-delivery, leading to improved survival rates of children in their first year of life. Optimizing maternal healthcare services in a resource-limited setting like Ethiopia is strongly recommended to reduce infant mortality. The findings from this study may provide important information for identifying priority interventions for maternal and infant

survival strategies and for developing policies and programs that can help to achieve the SDGs. It may also have important implications for maternal and child health programs in Ethiopia.

Abbreviations

CSA: Central Statistics Agency

EA: Enumeration Area

EDHS: Ethiopia Demographic and Health Survey

MDGs: Millennium Development Goals

PHC: Ethiopia Population and Housing Census

SDGs: Sustainable Development Goals

USAID: United States Agency for International Development

WHO: World Health Organization

Declarations

Ethics approval and consent to participate

The EDHS sought written informed consent and was approved by the study participants during data collection. The confidentiality of the respondents was also assured by the EDHS. Approval was obtained from the Human Research Ethics Committee of the University of Newcastle [Reference No: H-2018-0386]. A letter of approval was also obtained from MEASURE EDHS to use the dataset. The information obtained from the dataset was not disclosed to any third persons.

Consent to publication

Not applicable.

Availability of data and materials

Data will be available upon reasonable request from the corresponding author.

Competing interests

The authors declare that they have no competing interests.

Funding

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Authors' Contributions

GK: conceived the study, carried out the statistical analysis, and draft the manuscript. CC: Writing, review & editing the manuscript. DK: statistical analysis, writing, review. DL: Writing, review & editing the manuscript. All authors read and approved the final manuscript.

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Tables

Due to technical limitations, table 1 is only available as a download in the Supplemental Files section.

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