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Determinant of infant mortality in Ethiopia: demographic, socio economic, maternal and environmental factors

Abstract

Background: Infant mortality reflects the effect of social, economic and environmental factors on infants and mothers, as well as the effectiveness of national health systems. Infant mortality remains a big challenge for the Ethiopian mothers and government due to the high infant mortality rates. This study aimed to examine and identify the significant determinants of infant mortality in Ethiopia.

Methods: The multivariable binary logistic regression analysis was conducted. The data from the Ethiopia Demographic and health Survey of 2011 and 2016 was used.

Result: The infant mortality reduced during the periods of between2011 and 2016. marital status (OR=0.51;95%CI: 0.27-0.951) of not married, mother's age at first child birth((OR=0.69; 95%CI:0.48-0.994 of 15-19) and (OR=0.452;95%CI:0.302-0.68) of mothers age at first birth above 20 years), birth order(OR=0.183;95%CI:0.134-0.251) of order 2-3 and (OR= 0.416; 95%CI: 0.21,0.82) of order≥4, preceding birth interval(OR=0.64;95%CI:0.48-0.862) of >24 months are revealed that a significant effect on infant mortality in Ethiopia. Moreover, regarding to the socio-economic variables such as region: Benishangul Gumuze (OR=1.62; 95%CI: 1.003-2.601) revealed that a significant effect of infant mortality compared to Tigray region. Again, the variable family size ((OR=0.18; 95%CI: 0.11-0.3 of 4-6 family size) and (OR=0.163; 95%CI:0.093-0.29 of ≥7 family size)) showed that significant effect on infant mortality in 2011 EDHS.

Conclusion: Infant mortality was still high in Ethiopia. The findings declared that infant mortality can be reduced substantially by increasing the mother's age at first birth, duration of breastfeeding and birth interval. Variability among region, marital status, birth order, family size and father education level were also an important significant factor for infant mortality. This finding strongly suggests that, promoting family planning to improve the length of breastfeeding will improve birth intervals and reduce the incidence of higher birth orders at short birth intervals needs to decline the risk of infant mortality.

Keywords: infant mortality, breastfeeding, Ethiopia, EDHS, mother

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Abbreviations: CSA, central statistical agency; EAs, Enumeration Areas, EDHS, ethiopia demographic and health survey; FMoH, federal ministry of health; ICF, international child fund; IMR, infant mortality rate, PHC, population and house census; SNNPR: southern nations, nationalities, and people's region; UNICEF, united nations children's fund

Background

The infant mortality rate (IMR) is defined as the number of children who die before reaching their first birthday in a given year, expressed per 1000 live births, has in the past been regarded as a highly penetrating (representation) measure of population health. Mortality estimates calculated from birth histories depends on the mother's ability to recall all children she has given birth to, as well as their birth dates and ages at death. This reflects the apparent association between the causes of infant mortality and other factors that are likely to influence the health status of the whole populations such as their economic development, general living conditions, social wellbeing, rates of illness, and the quality of the environment.[1,2] Evidence on infant and child mortality is relevant to a demographic assessment of the population, and is an important indicator of a country's socioeconomic development and quality of life. It can also help to estimate how many children may be at higher risk of death and suggest the strategies to reduce this risk.

Infant mortality reflects the effect of social, economic and environmental factors on infants and mothers, as well as the effectiveness of national health systems. It can be deduced through cost-effective and proper interventions of committed individual and organization.[2] These include early and exclusive breastfeeding for the first six months of life, and the management of treatments of neonatal infections, pneumonia, diarrhea and malaria.[3] Oral rehydration therapy is a cheap and effective means to offset the debilitating effects of diarrhea,[3,4] and countries could also implement relatively inexpensive public health interventions including immunization, and provide clean water and sanitation. IMR also varies through different geographical location.

Health and income are associated both within and across countries, yet the extent to which advances in inverse relationship between economic modernization predictors such as the level of development and infant mortality.[5] In developing countries, including Africa, mortality among the under-five is greatest during infancy. A report indicates that about 80% of these infant deaths occurred in the first 6 months of life and two-thirds of the post neonatal deaths occurred before 6 months.[6] This may need that, so much greater attention must be given to the very young infant, if the problem of high infant mortality is to be tackled effectively. There is also an evidence that in many developing countries faltering in growth begins as early as 2-3 months of age.[7] This has led us to examine the pattern of mortality in the first year of life.

Various economic, political, and social factors found to be predicted that infant mortality in past cross-national studies continue to do so in our study as well. Decreasing in infant mortality may also be connected to the education of women via fertility reductions,[8] for a complete discussion on how education tends to reduce fertility levels in the developing world. Under conditions of limited resources, reducing the number of children allows the provider to allocate more time and finance to each child. These children will be better fed and clothed, generally better cared for, and, therefore, healthier. In addition, better-educated mothers will be more knowledgeable about health and safety risks as well as nutrition, all of which improve the health of children and reduce infant mortality.[9]

Ethiopia is one of the low income and second most populous countries in sub-Saharan Africa. Ethiopia is faced with many social and economic problems.[10] The high fertility of the population is attributed to low levels of contraception, cultural values favoring large family size, low socioeconomic development and high infant and child mortality. In view of this most Ethiopians are suffering from the lack of basic needs of life such as food, clothing, housing, and health care, education, safe, and healthy environment as consequences of the uncontrolled and rapid increase of population growth.[11]

In Ethiopia, infant and child mortality is still high. According to the 2016 EDHS report in Ethiopia 1 in every 35 children dies within the first month, 1 in every 21 children dies before celebrating the first birthday, and 1 in every 15 children dies before reaching the fifth birthday. The report also showed that, infant mortality also declined from 97deaths per 1,000 live births in 2000 to 77 deaths per1,000 live births in 2005 and also declined from 59 deaths per1,000 live births in 2011 to 48 deaths per1,000 live births in 2016.[12-15] Neonatal mortality declined from 49 deaths per 1,000. In general, infant mortality in Ethiopia were decline from 97deaths per 1,000 live births in 2000 to 48 deaths per1,000 live births in 2016, which is about a 50%reduction in the last 16 years.[13]

Although successive EDHS have shown a decline in infant mortality; but, still it is high. Furthermore, it is very important to generate discussion on declining infant mortality and what factors contribute the most to the reduction of infant mortality in Ethiopia in the period of 2011 and 2016 EDHS's, using the two periods of Demographic and Health Survey Data. This study examined in different ways, child and mother's demographic and socio-economic characteristics. Now, the issue is how infant mortality declined in Ethiopia? At what level? Is it true or not? The aim of this study was to investigate the demographic, maternal, environmental and socio-economic factors impact on infant mortality.

Methods

Source of Data

The data found from the Ethiopia Demographic and Health Surveys of 2011 and 2016 were used for this study. The dataset consists of a national representative sample of household's level data. It was implemented by the Central Statistical Agency (CSA) at the request of the Federal Ministry of Health (FMoH). The two surveys comprising women aged between 15 and 49 years, and men aged between 15 and 59 years. The EDHS data provides socio-economic information about the mother and her household, such maternal education level, the household's ownership of selected material assets, and where the household lives. The two surveys contain the detailed information about women aged 15-49 years, coving topics such as education, fertility levels, marriage, sexual activity, fertility preferences, awareness and use of family planning methods, breastfeeding practices, nutritional status etc. All eligible women are asked about their birth history, providing information about the date of birth, survival status and, if dead, date of death of each infant reported by a woman. The birth history provides information about the demographic characteristics of the child, age of mother at the time of birth, birth order of the child, and preceding birth interval. The woman's information dataset was used in the empirical analysis. The two surveys record information about health variables for births in defined periods prior to the survey time.

Study and Target Population

The target population was all infants during 2011 and 2016 study period in Ethiopia, while the study population was all infants in randomly selected enumeration areas (EAs) in Ethiopia.

Sampling Design

The sampling frame used for the 2011 and 2016 EDHS is the Ethiopia Population and Housing Census (PHC), which was conducted in 2007 by the Ethiopia Central Statistical Agency. The sampling frame contains information about the EA location, type of residence (urban, rural), and estimated number of residential households. Samples of EAs were selected independently in each stratum in two stages. So, EDHS uses multistage sampling.

Study Variables

The dependent variable in the current study was dichotomous. Since there are two different outcomes, a child either survives the first birth day, or dies. The dependent variable categorized as infant death occurred (yes) and infant death not occurred (no).

The independent variables considered in this study were fathers' and mothers' educational status, fathers' and mothers' occupation, the presence of multiple twin, region of the families were lived in, current marital status of mothers, age of mothers at first birth, source of drinking water, type of toilet facility, duration of breastfeeding, birth order number, place of residence, use of the contraceptive method, family size, wealth index, sex of child, mother's age group (at the survey time), head of the household, usage electricity, and preceding birth interval. Those variables were considered due to the availability in the dataset and previous literature studies. The variables were categorized to make it easy for analysis purpose.

Statistical Model

Pearson chi-square (x^2) and binary logistic regression were conducted for data analysis using STATA 14 software. The chi-square test of association was used to statistically test whether the significant association was existed between infant mortality and other independent categorical variables or not. To determine the significant factor of infant mortality, the response variable was categorized as follows: infant death occurred (yes) and infant were survived (no), and a binary outcome and logistic regression were employed. A p-value ≤ 0.05 is used to test the presence of the significant association between the dependent and independent variables.

Odds ratio is the change in odds for a unit change in the predictor. That is, when the odds ratio is less than 1, increasing values of the variable correspond to decreasing odds of the events occurrence (infant death). When the odds ratio is greater than 1, increasing values of the variable means increasing likelihood of the occurrence.

Results

This study examine the infant mortality in Ethiopia in 2011 and 2016 DHS data set, a number of exciting results have been reached.

The results showed in Table 1 were the changes in infant mortality rates based on the impacts of demographic factors in 2011 and 2016 EDHS, the mothers' age at first birth ($x^2 = 68.84, p-value \leq 0.001, and\ x^2 = 32.52, p-value \leq 0.001$) , preceding birth interval ($x^2 = 94.324, p-value \leq 0.001, and\ x^2 = 25.5, p-value \leq 0.001$), and birth order ($x^2 = 542.05, p-value \leq 0.001, and\ x^2 = 290.44,\ p-value \leq 0.001$) shows a significant association between those variables and infant mortality in 2011 and 2016; respectively.

The factor birth type with $x^2 = 13.13,\ and\ p-value \leq 0.001$ in 2016 had significantly associated. Moreover, marital status $(x^2 = 14.38, p-value \leq 0.001)$ in 2011 had significant association, and the change of infant death among married women was reduced by 0.6%, while the change among currently not married women was increased by 0.6% from 2011 to 2016. Similarly, the change of infant death among mothers' age at first birth was increased by 6.9% and 4.5% to the age group of <15 and >20 years; respectively and it was declined by 11.3% to the age group of 15-19 years from 2011 to 2016. The change of infant mortality among mother preceding birth interval was increased, and decreased by 11.9% for 24months and younger and older than 24 months respectively, from 2011 to 2016. The change of infant mortality was increased by 21.6% and 16.5% to the first and 2-3 birth order respectively and declined by 38.1% to 4 and above birth order. And also, the death of single child was decreased by 0.4%, while, for multiple children it was increased by 0.4% from 2011 to 2016. Infant mortality among male child from 2011 to 2016 was declined by 3%, but, for female children it was increased by 3%.

Table 1 Changes in infant Mortality Rates by selected demographic factors on infant mortality (EDHS: 2011 and 2016)

Variable	Infant mortality in EDHS 2011(n=2011)	Chi-square (p-value)	Infant mortality in EDHS 2016(n=2016)	Chi-square (p-value)
	Death occurred (%)		Death occurred (%)	
Marital status				
Married	699(97.4)	14.38	541(96.8)	1.2017 (P=0.273)
Not married	19(2.6)	(P≤0.001)	18(3.2)	
Mother's age at first child birth				
<15	87(12.1)	68.84	106(19)	32.52 (P≤0.001)
15-19	423(58.9)	(P≤0.001)	266(47.6)	
>20	208(29)		187(33.5)	
Birth interval				
<=24 month	123(17.1)	94.324	162(29)	25.5
>24month	595(82.9)	(P≤0.001)	397(71)	(P≤0.001)
Birth order				
First	0(0)	542.05	27(21.6)	290.44
2-3	113(15.7)	(P≤0.001)	101(32.2)	(P≤0.001)
4 and above	605(84.3)		431(46.2)	
Birth type				
Single	700(97.5)	2.28	543(97.1)	13.13
Multiple	18(2.5)	(P=0.131)	16(2.9)	(P≤0.001)
Sex of child				
Male	362(50.4)	0.04	265(47.4)	2.01
Female	356(49.6)	(P=0.841)	294(52.6)	(P=0.15)

The change in death occurred from 2011 to 2016 among mothers educational level primary school complete, secondary school complete, and having higher educational level was increased 0.4%, 3.7%, and 0.6%; respectively. However, it was declined by 4.5% for illiterate mothers. The change in infant mortality from 2011 to 2016 among father education level was declined by 1.5%, 1.8% and 0.2% for illiterate, primary and secondary education level; respectively. However it was increased by 3.6% for higher education level of fathers. The change in infant mortality from 2011 to 2016 was increased by 53.7% for not working and decreased by 53.7% working mother.

Similarly, the change in infant mortality from 2011 to 2016 was increased by 8.6% for not working. The change in infant mortality from 2011 to 2016 was increased by 81% for children from urban areas. And also, high infant death was occurred in 2011 in Oromia region (17.8%) and low death was occurred in Addis Ababa (0.4%), in 2016 high infant death was occurred in Somali (18.6%), while, low death was occurred in Addis Ababa (1.3%). This implies that there is geopolitical regional level difference is occurred in infant mortality. The change in infant mortality from 2011 to 2016 among wealth index status was increased by 6.3% for poor groups and declined by 6.25 and 0.1% in middle- and rich-income groups. The change in infant mortality from 2011 to 2016 was increased by 5.6% and 1.1% for 1-3 and 4-6 household size, and declined by 5.5% for seven and above family size. The result also showed that the change in infant mortality from 2011 to 2016 was increased by 4% for female household head.

Regarding the chi-square test of association results, the variable mother educational level ($x^2 = 104.98, p-value \leq 0.001 and\ x^2 = 100.6, p-value \leq 0.001$) ; place of residence ($x^2 = 46.17, p-value \leq 0.001 and\ x^2 = 41.7, p-value \leq 0.001$) ; region($x^2 = 61.5, p-value \leq 0.001 and\ x^2 = 35.71, p-value \leq 0.001$) ; wealth index($x^2 = 39.57, p-value \leq 0.001 and\ x^2 = 43.03, p-value \leq 0.001$) ; father education level ($x^2 = 87.48, p-value \leq 0.001, and x^2 = 70.18, p-value \leq 0.001$) ; and family size($x^2 = 94.34, p-value \leq 0.001 and\ x^2 = 37.07, p-value \leq 0.001$) was significantly associated with infant mortality in 2011 and 2016. Similarly, sex of the household was significantly associated ($x^2 = 5.88, p-value = 0.015$) with infant mortality, in 2011 EDHS. (Table 2)

Table 2 Changes in infant Mortality Rates by selected socio-economic factors on infant mortality (EDHS: 2011 and 2016)

Variable	Infant mortality in EDHS 2011(n=2014)	Chi-square (p-value)	Infant mortality in EDHS 2016(n=2014)	Chi-square (p-value)
	Death occurred (%)		Death occurred (%)	
Mother education level				
No education	581(80.9)	104.98	427(76.4)	
Primary	127(17.7)	(P≤0.000)	101(18.1)	100.6
Secondary	8(1.1)		26(4.7)	(p≤0.000)
Higher	2(0.3)		5(0.9)	
Father education level				
No education	426(59.3)		323(57.8)	
Primary	239(33.3)	70.18	176(31.5)	87.48
Secondary	35(4.9)	(P≤0.001)	26(4.7)	(P≤0.001)
Higher	18(2.5)		34(6.1)	
Mother occupation				
Working	538(75)	0.823	440(21.3)	0.1257
Not work	179(25)	(P=0.364)	119(78.7)	(P=0.723)
Father/parent occupation				
Working	708(98.6)	0.885	56(90)	1.2
Not work	10(1.4)	(P=0.347)	503(10)	(P=0.274)
Place of Residence				
Rural	655(91.2)	46.17	502(10.2)	41.7
Urban	63(8.8)	(P≤0.001)	57(89.8)	(P≤0.001)
Region				
Tigray	69(9.6)		49(8.8)	
Afar	52(7.2)		63(11.3)	
Amhara	85(11.8)		57(10.2)	
Oromia	128(17.8)		81(14.5)	
Somalia	77(10.7)	61.5	104(18.6)	35.71
Benishangul Gumuz	80(11.1)	(P≤0.001)	46(8.2)	(P≤0.001)
SNNPR	123(17.1)		70(12.5)	
Gambela	44(6.1)		29(5.2)	
Harari	25(3.5)		26(4.7)	
Dire Dawa	32(4.5)		27(4.8)	
Addis Ababa	3(0.4)		7(1.3)	
Wealth index				
Poor	417(58.1)	39.57	360(64.4)	43.03
Medium	131(18.2)	(P≤0.001)	67(12)	(P≤0.001)
Rich	170(23.7)		132(23.6)	
Family size				
1-3	40(5.6)	94.34	56(10)	37.07
4-6	295(41.1)	(P≤0.001)	236(42.2)	(P≤0.001)
≥7	383(53.3)		267(47.8)	
Sex of house hold				
Male	612(85.2)	5.88	454(81.2)	1.202
Female	106(14.8)	(P=0.015)	105(18.8)	(P=0.273)

The change in maternal factors on infant mortality from 2011 to 2016, the change in death occurred among duration of breast-feeding children <6 months and ≥16months was increased by 16.7%. The change in infant mortality from 2011to 2016 among users of contraceptive method and not used was decreased by 80.6%. The change in infant mortality from 2011to 2016 among age group of mothers from 15-19 and 20-25 was increased by 0.8% and 4.3 respectively; while, it was declined by 5.1% for the age group >25 years. And also, the variable use of contraceptive methods ($x^2 = 45.9, p-value = 0.01 and\ x^2 = 24.3, p-value \le 0.001$) , and mothers age group ($x^2 = 244, p-value = 0.01 and\ x^2 = 105.5, p-value \le 0.001$) was significantly associated with infant mortality in 2011 and 2016. Duration of breastfeeding ($x^2 = 81.99, p-value = 0.01$) had significantly associated with infant mortality in 2016. (Table 3)

Sources of drinking water ($x^2 = 6.59, p-value = 0.01 and\ x^2 = 12.46, p-value \le 0.001$) , and electricity ($x^2 = 54.2, p-value \le 0.001 and\ x^2 = 41.95, p-value \le 0.001$) had significant association with infant mortality in 2011 and 2016. And also, the types of toilet facility had significantly associated ($x^2 = 21.78, p-value \le 0.001 \le 0.001$) , only in 2016. The change in death occurred during 2011 to 2016 among protected drinking water was increased by 9% for unprotected drinking water. The change in death occurred during 2011 to 2016 among use of toilet facility was increased by 4.1% of who had no formal toilet facility. The change in infant death occurred during 2011 and 2016 among electricity user and non-user was increased and decreased by 75.8%; respectively. (Table 4)

Table 3 Changes in infant Mortality Rates by selected maternal factors on infant mortality (EDHS: 2011 and 2016)

Variable	Infant mortality in EDHS 2011(n=2014)	Chi-square (p-value)	Infant mortality in EDHS 2016(n=2014)	Chi-square (p-value)
	Death occurred (%)		Death occurred (%)	
Duration of breast feeding				
<6 months	17(2.4)	1.5	107(19.1)	81.99
≥ 6 months	701(97.6)	(P=0.22)	452(80.9)	(P=0.01)
Use of contraceptive				
Yes	673(93.7)	45.9	73(13.1)	24.3
No	45(6.3)	(P≤0.001)	486(86.9)	(P≤0.001)
Current age of mother				
15-19	14(1.9)	244	15(2.7)	105.5
20-25	127(17.7)	(P≤0.001)	123(22)	(P≤0.001)
>25	577(80.4)		421(75.3)	

Table 4 Changes in infant Mortality Rates by selected environmental factors on infant mortality (EDHS: 2011 and 2016)

Variable	Infant mortality in EDHS 2011(n=2014)	Chi-square (p-value)	Infant mortality in EDHS 2016(n=2014)	Chi-square (p-value)
	Death occurred (%)		Death occurred (%)	
Source of drinking water				
Protected	263(36.6)	6.59	255(45.6)	12.46
Unprotected	455(63.4)	(P=0.01)	304(54.4)	(P≤0.001)
Type of toilet facility				
Flush	307(42.8)	0.24	262(46.9)	21.78
Other	411(57.2)	(P=0.63)	297(53.1)	(P≤0.001)
Electricity				
Yes	79(11)	54.3	74(86.8)	41.95
No	639(89)	(P≤0.001)	485(13.2)	(P≤0.001)

Results of the binary logistic regression analysis for the 2011 were shown Table 5. Due to the existence of many demographic, socio-economic, maternal and environmental factors included in the current study, we cannot check the interaction terms of the factors. This might be the limitation in this multivariable analysis. Individual variables were included in the multivariable regression model, if it was significant at $p \leq 0.25$ in univariable analysis. Preliminary with the result of multivariable regression model, marital status (OR=0.51;95%CI: 0.27-0.951) of not married, mother's age at first child birth((OR=0.69; 95%CI:0.48-0.994 of 15-19) and (OR=0.452;95%CI:0.302-0.68) of mothers age at first birth above 20 years), birth order(OR=0.183;95%CI:0.134-0.251) of order 2-3 and (OR= 0.416; 95%CI: 0.21,0.82) of order≥4, preceding birth interval(OR=0.64;95%CI:0.48-0.862) of >24 months are revealed that a significant effect on infant mortality in Ethiopia. Moreover, regarding to the socio-economic variables such as region: Benishangul Gumuze (OR=1.62; 95%CI: 1.003-2.601) revealed that a significant effect of infant mortality compared to Tigray region. Again, the variable family size ((OR=0.18; 95%CI:0.11-0.3 of 4-6 family size) and (OR=0.163; 95%CI:0.093-0.29 of ≥7 family size)) showed that significant effect on infant mortality in Ethiopia.

Table 6 below revealed that results of multivariable logistic regression analysis for the 2016. According to the result of multivariable regression model, mother's age at first child birth(OR=0.695;95%CI:0.512-0.942) of age group 15-19, birth order ((OR=7.59;95%CI:4.16-13.84 of order 2-3) and (OR=41.6; 95%CI: 20.72-83.5 of order ≥ 4), preceding birth interval(OR=0.597;95%CI:0.451-0.79) of interval >24 months are revealed that a significant effect on infant mortality in Ethiopia.

Regarding to the socio-economic variables such as, father education level secondary school completed (OR=0.422; 95%CI: 0.27-0.74) revealed that a significant effect of infant mortality in Ethiopia compared to non-educated father. Again, the variable family size ((OR=0.242; 95%CI: 0.15-0.39 of size 4-6 child) and (OR=0.169; 95%CI: 0.1002-0.284 of size ≥ 7child)) showed that significant effect on infant mortality in Ethiopia. According to the maternal factor the variable duration of breast feeding (OR=0.2; 95%CI: 0.142-0.283) of feeding breast more than 6 months was a significant effect of infant mortality in Ethiopia compared to mothers feed their breast less than or equal to 6 months.

Table 5 Result of Binary logistic analysis: multivariable analysis on infant mortality (2011)

Variable	OR (95%CI)	Standard error	P>|z|
Marital status(Married)			
Not married	0.51(0.27, 0.951)	0.162	0.034*
Mother's age at first child birth(<15)			
15-19	0.69(0.48,0.994)	0.13	0.046*
>20	0.452(0.302, 0.68)	0.093	≤0.001*
Birth interval(≤24 month)			
>24month	0.64(0.48,0.862)	0.096	0.003*
Birth order (First**)**			
2-3	0.183(0.134,0.251)	0.03	≤0.001*
4 and above	0.416(0.21,0.82)	0.15	≤0.001*

Table Continued...

Variable	OR (95%CI)	Standard error	P>|z|
Mother education level (No education)			
Primary	0.76(0.573,1.01)	0.11	0.057
Secondary	1.134(0.46,2.814)	0.53	0.786
Higher	1.301(0.24,7.084)	1.13	0.761
Father education level (No education)			
Primary	0.834 (0.66,1.063)	0.103	0.142
Secondary	1.073 (0.634,1.82)	0.29	0.793
Higher	0.58 (0.294,1.03)	0.176	0.061
Place of Residence (Urban)			
Rural	1.242(0.8,1.95)	0.29	0.346
Region (Tigray)			
Afar	0.783(0.47,1.3)	0.202	0.344
Amhara	1.044(0.663,1.644)	0.242	0.854
Oromia	1.104(0.724,1.683)	0.24	0.647
Somalia	1.023(0.64,1.65)	0.25	0.924
Benishangul Gumuz	1.62(1.003,2.601)	0.393	0.049*
SNNPR	1.372(0.89,2.12)	0.304	0.154
Gambela	1.05(0.61,1.81)	0.29	0.863
Harari	0.698(0.372,1.31)	0.224	0.263
Dire Dawa	0.73(0.42,1.27)	0.21	0.260
Addis Abeba	0.298(0.08,1.13)	0.202	0.074
Wealth index (Poor)			
Medium	0.854(0.64,1.14)	0.05	0.282
Rich	0.814(0.594,1.12)	0.132	0.205
Family size (1-3)			
4-6	0.18(0.11,0.3)	0.05	≤0.001*
≥7	0.163(0.093,0.29)	0.05	≤0.001*
Sex of house hold (Male)			
Female	0.954(0.69,1.32)	0.16	0.773
Use of contraceptive (No)			
Yes	0.74(0.49,1.12)	0.16	0.15
Duration of breast feeding (<6 month)			
≥ 6 month	1.343(0.705,2.56)	0.442	0.370
Current age of mother (15-19)			
20-25	0.824(0.41,1.7)	0.3	0.591
>25	1.49(0.72,3.1)	0.56	0.29
Source of drinking water (Unprotected)			
Protected	1.02(0.81,1.3)	0.123	0.855
Electricity (No)			
Yes	1.13(0.733,1.742)	0.25	0.580
Constant	7.801(2.205,27.6)	5.03	0.001*

Table 6 Result of Binary logistic analysis: multivariable analysis on infant mortality (2016)

Variable	OR (95%CI)	Standard error	P>|z|
Mother's age at first child birth (<15)			
15-19	0.95(0.512,0.942)	0.11	0.019*
≥20	0.77(0.55,1.1)	0.134	0.131
Birth interval (≤24 month)			
>24month	0.597(0.451,0.79)	0.09	≤0.001*
Birth order(First)			
2-3	7.59(4.16,13.84)	2.33	≤0.001*
≥4	41.6(20.72,83.5)	14.8	≤0.001*
Birth type (Single)			
Multiple	1.76(0.81,3.83)	0.698	0.157
Sex of child (Male)			
Female	1.17(0.943,1.45)	0.13	0.155
Mother education level(No education)			
Primary	0.862(0.64,1.164)	0.132	0.333
Secondary	1.453(0.84,2.52)	0.41	0.185
Higher	0.64(0.222,1.82)	0.341	0.398
Father education level(No education)			
Primary	0.942(0.725,1.223)	0.13	0.651
Secondary	0.442(0.27,0.74)	0.12	0.002*
Higher	0.7111(0.44,1.16)	0.18	0.173

Table Continued...

Variable	OR (95%CI)	Standard error	P>|z|
Place of Residence (Urban)			
Rural	1.47(0.901,2.4)	0.367	0.123
Region (Tigray)			
Afar	1.04(0.634,1.71)	0.264	0.872
Amhara	1.29(0.782,2.13)	0.33	0.319
Oromia	0.893(0.57,1.41)	0.206	0.624
Somalia	0.92(0.58,1.46)	0.22	0.717
Benishangul Gumuz	0.96(0.58,1.603)	0.251	0.876
SNNPR	1.24(0.77,1.998)	0.302	0.38
Gambela	0.96(0.524,1.744)	0.293	0.883
Harari	0.68(0.368,1.26)	0.213	0.218
Dire Dawa	1.67(0.91,3.09)	0.523	0.806
Addis Abeba	0.89(0.343,2.298)	0.431	0.099
Wealth index (Poor)			
Medium	0.74(0.511,1.06)	0.14	0.101
Rich	0.92(0.64,1.331)	0.173	0.662
Family size(1-3)			
4-6	0.242(0.15,0.39)	0.06	≤0.001*
≥7	0.169(0.1002,0.284)	0.045	≤0.001*
Duration of breast feeding (<6 month)			
≥6 month	0.2(0.142,0.283)	0.035	≤0.001*
Use of contraceptive(No)			
Yes	1.003(0.717,1.403)	0.172	0.988
Current age of mother (15-19)			
20-25	0.88(0.45,1.73)	0.303	0.71
>25	1.12(0.53,2.4)	0.43	0.767
Source of drinking water (Unprotected)			
Protected	0.98(0.774,1.24)	0.12	0.863
Type of toilet facility (Other)			
Flush	0.93(0.71,1.22)	0.13	0.594
Electricity (No)			
Yes	1.04(0.66,1.64)	0.241	0.865
Constant	0.47(0.174,1.26)	0.236	0.132

Discussion

The study has examined the infant mortality in Ethiopia in 2011 and 2016 EDHS's. Even though, the evidence shows that in Ethiopia, the decline of infant mortality is pragmatic; it is still high in national level and has identified multiple risk factors for infant mortality based on the characteristics of mothers, fathers, and children and the different environments of child birth. The main reason for this discrepancy could be the difference in socio-economic status, health facility coverage, and other infrastructures related to child and mother health. The concern of some findings from previous studies was limited as most studies in Ethiopia restricted their analyses to the whole death of infant mortality; separately for both the previous five year of 2011 and 2016 in the country instead of for both years of study.[12-15]

Demographic such as mother's age at first child birth is significantly associated with infant mortality for both previous five years of 2011 and 2016.For both years the variable "mother's age at first child birth" was inversely associated with infant mortality rate. Infants born from mothers, who were younger than 15 years old at the first birth experienced high risk of dying. The result showed that in 2011, the odds of mothers aged at first birth 15-19 years and greater than 20 years were 0.69 and 0.45 times less likely to face infant mortality as compared to with mothers who are younger than 15 years old at the first birth. Similarly, in 2016, the odds of mothers aged at first birth 15-19 years were 0.695 times less risk of infant mortality as compared to mothers who were younger than 15 years old at the first birth, holding other variables constant. This study was consistent with the previous study shows that, age at first birth can influence child mortality through different perspectives. Most importantly, the covariate age of mother was still found to be significantly increase the risk of death of infant born at an early age of the mother.[16,17] This was happened due to higher risk of child death among younger mothers pertains because of immature reproductive systems, engaged at early age and less stability to handle the complexities of childbirth.

However, the variable marital status of the mothers had significantly impact on infant deaths in 2011. The odds of not married mothers during survey time were 0.51 times less risk of infant mortality than married mothers. The reason might be they give due attention/care only for their new child than other family members. The limitation of resources is introduced on the notion that usually large households are associated with low resource per head which adversely impacts on child health and survival.[18] The cultural factor in Ethiopia has an influence for mothers with their husband that stretch load for child and household protection.

The demographic variables birth order and preceding birth interval are significantly associated with infant mortality for both previous five years of 2011 and 2016. The result indicated that in 2011, the odds of infant for 2-3, and four and above birth order was 0.183 and 0.416 times less risk of infant death than first birth order, respectively. While, in 2016, the odds of infant of 2-3, and four and above birth order were 7.6 and 41.6 times more likely to risk of infant death than first birth. This study implies that as the child birth order increased the risk of infant death also increased. This result is differed from 2011

to 2016; this may happen due to health service and health extension in the country was flourished. The EDHS 2016 shows a slight decline in the infant mortality levels in the national level. This decline might be quite expected. However, the difference might be due to poor data quality pertaining to classification in 2011 EDHS data as compared to 2016 EDHS. The birth order increased child mortality, in which it was clearly integrated with the result that the child death rate decreases with the increasing of birth interval with previous child. This result was consistent with the previous different studies regarding birth order.[19-21]

This study revealed that, the socio-economic variable family size was significantly associated with infant mortality for both previous five years of 2011 and 2016. The odds of the number of household size 4-6 and seven and above ((OR=0.18 in 2011 and OR=0.242 in 2016) and (OR=0.163 in 2011 and OR=0.169 in 2016)) had lower risk of infant mortality rate than number of household 1-3. This result was in lined with the previous studies undergone in Ethiopia.[16,22,23] Then this result implies that, the variable household size was identified statistically correlated with infant mortality, infants born of mother who lived with large size of household were more likely to face infant death than those infants of mother with small household size. This result also support the previous study analysis, combined family planning through contraceptive methods, and immunization through vaccination provide a higher impact on the achievement of child health goals.[20] The large family size associated with the foregoing could practically reduce parent–child emotional attachments, which is crucial in promoting active childcare. Moreover, the limitation of resources in household resources for the conservation of children might lead to poor living conditions which could possibly increase the vulnerability of infant to diseases and subsequently to death. The lack of resources can also limit access to modern healthcare particularly with the cash-and-carry system operated in several developing and SSA (sub-Saharan Africa) countries. The consequence was that children from large family household size might be less provided for, more vulnerable and consequently exposed to higher risk of death.[18]

The variable region had a significant impact on infant death in 2011 EDHS: the odds of infant mortality in Beninshangul Gumuz were 1.65 times more likely to risk of infant death occurred than Tigray region. The possible reason could be these regions are also known for socio-economic vulnerability and food insecurity leading to malnutrition and infant death. The reason why infant mortality were high in Benishangul gumuze was low level of maternal education, mothers having more than two under five children, antenatal care service utilization, and higher birth order,[24,25] the culture and the health lifestyle in Beninshangul Gumuz community was still not changed as civilized nation and still there was also scarce health facility and institution compared to other region.[23,26]

The socio-economic factor father's educational level was a significant relationship with infant mortality for previous five years of 2016: this study revealed that father education level of secondary school complete had lower of (OR=0.422) time under risk of infant mortality than non-educated father. So, this study coincides with the higher level of education, the better attainment of childcare practices. It also shows that educated fathers could intend to capture knowledge level of childcare. The results of the current study supported that "Infants born to parents with a higher degree of education experience a decreased risk of dying". Educated parents are more likely to be aware of health care utilization to themselves their children and the community and also education play a vital role to remove cultural barriers and keep the health of the household to reduce infant mortality. Improvements in access to education have helped to narrow the gender gap and have benefited the poorest households.[16,20]

Additionally, preceding birth interval was found a significant impact on infant deaths in both previous five years of 2011 and 2016. The preceding birth interval of greater than 24months has lower (OR=0.64 in 2011 and OR=0.597 in 2016) risk of infant mortality rates than less than 2 years birth interval. It was pointed out that shorter birth intervals increase the risk of infant mortality. This coincides with the reality that in Ethiopia when birth intervals are short, breastfeeding mothers terminated within a few months after birth, leading to poor child health.[16,27] Due to that the proper spacing of births allows more time for childcare to make more maternal resources available for the care of the child and the mother.

However, the current study shows, the maternal duration of breastfeeding was a significant relationship with infant mortality for the previous five years of 2016: the odds of infant death for duration of breastfeeding mothers six and above months were0.2 times less likely to risk of infant dying than the duration of breastfeeding less than 6 months children. This is probably because of those mothers' duration of breastfeeding less than 6 months can afford good nutrition, unlike the duration of breastfeeding mothers six and above months, and have time to be with their babies. This study was coincided with the study.[10,19]

In general, developing countries like Ethiopia infant mortality is often thought to be higher in rural areas than urban areas because of differences in standards of living, health conditions and availability of or access to public health facilities and services.

Moreover, marital status, father's educational level, duration of breastfeeding was the only significantly correlated factors with infant mortality for previous five years of 2011 and 2016; respectively.

Conclusion

The infant mortality in developing nations like Ethiopia is still a public health problem, and this study tried to identify the most significant demographic and socio-economic factors that associated with the reduction in infant mortality in Ethiopia during the previous five years of 2011 and 2016.According to infant mortality model, the findings declared that infant mortality can be reduced substantially by increasing the mother's age at first birth, duration of breastfeeding and birth interval. And also, variation in region, marital status, birth order, family size and fathers' education level were also an important significant factor for infant mortality. This finding strongly suggests that, promoting family planning to improve the length of breastfeeding will improve birth intervals and reduce the incidence of higher birth orders at short birth intervals needs to decline the risk of infant mortality. Finally, this finding specified that an increase in mothers' age at first birth, improve health care services which should in turn raise child survival and should decrease infant mortality in Ethiopia.

Declarations

Data Availability

The data for this study were sourced from Demographic and Health Surveys (DHS) and are available at http://www.dhsprogram.com/data/available-datasets.cfm.

Ethics approval and consent to participate

Written consent was obtained from the Measure DHS International Program which authorized the data-sets. The data used in this study were publicly available, aggregated secondary data with not having any personal identifying information that can be linked to particular individuals, communities, or study participants. Confidentiality of data maintained anonymously.

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Authors' Contributions

SS carried out the data extraction, designed the study, performed analysis and interpretation, and draft the manuscript. SG designed the study, participated in the analysis and interpretation of the drafted manuscript. Both authors read and approved the final manuscript.

Consent for publication

Not applicable.

Conflicts of interest

The authors declare there was no competing interest.

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