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Risk factors for under-5 mortality: evidence from Ethiopian Demographic and Health Surveys (DHS 2011 & 2016)

ABSTRACT

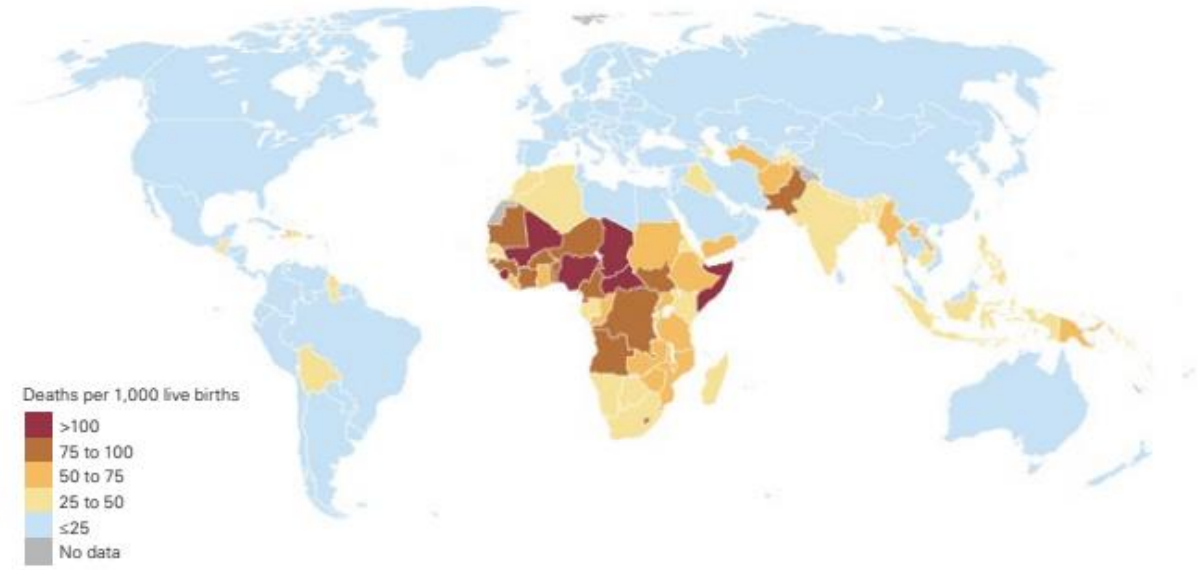
About 472,000 Ethiopian children die each year before their fifth birthday, ranking Ethiopia sixth among the countries of the world in terms of the absolute number of child deaths. *While the under-5 mortality rate in Ethiopia has declined by two-thirds from 204/1,000 live births in 1990 to 58/1,000 live births in 2016, the rate is still one of the highest among sub-Sharan African countries. In this study, we used data from the 2011 & 2016 Ethiopian Demographic and Health Surveys to examine factors that affect neonatal, infant, and under-5 mortality. Cox-proportional hazard models showed that children under 5 who were male, born from widowed/divorced/separated mothers who never used modern contraceptives, had a fifth or above birth rank, were born in health facilities without a cesarean session, or never received postnatal care or TT vaccinations had a significantly higher risk of dying. Findings were similar for neonatal and infant mortality.*

Introduction:

Globally 5.6 million children under the age of 5 died in 2016[1]. The global under-5 mortality rate declined by 56 percent, from 93 deaths per 1,000 live births in 1990 to 41 in 2016 [2]. In 2016, the under-5 mortality rate in low-income countries was 73.1 deaths per 1000 live births – almost 14 times the average rate in high-income countries (5.3 deaths per 1000 live births). More than half of under-5 child deaths are due to diseases that are preventable and treatable through simple, affordable interventions[3].

Sub-Saharan Africa is, by far, the region of the world with the highest level of under-5 mortality; approximately 41% of the global under 5 mortality is found in sub-Saharan Africa (SSA)[4]. Although under-5 child mortality rate declined by 52% between 1990 and 2015 (from 179 to 86 per 1000 live births) in sub-Saharan Africa, the continent still has the highest rate in the world[5].

Figure 1: Children in sub-Saharan Africa and Southern Asia face a higher risk of dying before their fifth birthday



Source: United Nations Inter-agency Group for Child Mortality Estimation (UN IGME)[6], 2017

A child's risk of dying is highest in the first 28 days of life (the neonatal period)[1]. 2.6 million babies die every year in their first month of life and a similar number are stillborn[1].This is when the mother and child should receive quality follow-up care to prevent and treat illness. Globally, the number of neonatal deaths declined from 5.1 million in 1990 to 2.6 million in 2016[3]. However, the relative decline in the neonatal mortality rate was slower in sub-Saharan Africa. The modest decline in neonatal mortality in this region was offset by an increasing number of births so that the number of neonatal deaths remained almost the same from 1990 to 2016[3].

Ethiopia is among the five least developed countries in sub-Saharan Africa that accounted for half of all newborn deaths next to India, Pakistan, Nigeria, and the Democratic Republic of the Congo [2]. About 472,000 Ethiopian children die each year before their fifth birthday, which places Ethiopia sixth among the countries of the world in terms of the absolute number of child deaths[7]. In Ethiopia, under-5 mortality rate has declined by two thirds from the 1990 figure of 204/1,000 live births to 58/1,000 live births in 2016, thus meeting the target for Millennium Development Goal 4 (MDG 4)[8-10]. However, the under-5 mortality rate in Ethiopia is still higher compared to the mortality rate in many low and middle-income countries (LMIC).

Previous studies have examined the socio-economic and demographic factors associated with under-5 mortality in Ethiopia [11-14]. Findings of these studies classify the risk factors into five categories: fertility behavior; breastfeeding and infant feeding; environmental health conditions; and socioeconomic status. Improvements in education, income, access to mass media, coverage and quality of health services, access to safe water and toilet facilities all play a role in reducing the infant and under-five mortality levels [14].

However, the factors associated with health facilities such TT vaccinations, combined mode of delivery (facilities with and without caesarean session), and postnatal care visits seem to be neglected so far. A study conducted in Kenya and Bangladesh [15, 16] however discovered that health-related factors were found to be significantly associated with neonatal, infant and under-5 mortality in developing countries. The recent Ethiopian Demographic and Health Survey [9], here after, "EDHS", also documented that the percentage of women with access to institutional delivery are only 26%; only 13% of newborns received a postnatal care check within two months after delivery; the percentage of women who received antenatal care visits are only 62% [17]; 51% of mothers had their last birth not received TT vaccinations.

Correspondingly, none of the previous studies [11-14] conducted so far have determined the factors associated with neonatal mortality separately. A child's risk of dying is highest in the first 28 days of life (the neonatal period)[1]. Improving the quality of antenatal care, care at the time of childbirth, and postnatal care for mothers and their newborns are all essential to prevent these deaths[1]. A study conducted in Bangladesh also found out that father's education, place of residence, housing materials, number of children under five years of age, and previous death of sibling have significant influence on neonatal mortality[14, 16].

The aim of the present study was therefore to identify specific factors that affect childhood mortality in Ethiopia at different sub periods of the first 59 months of life (neonatal, infant, and under-5 mortality). We employed 2000, 2005 and 2011 and 2016 versions of EDHS. Findings from this study may help policy-makers to redirect resources to the most vulnerable children who have a high risk of dying before the age of 5.

Data and methods

EDHSs are nationally representative household surveys that collect data on a wide range of population, health and nutrition indicators. And have been conducted approximately every 5 years since 2000 with the aim of improving the health of Ethiopian mothers and children. The sampling methods used in this study have been reported elsewhere [9, 18-20].

The data from four consecutive EDHS surveys (2000, 2005, 2011, and 2016) was obtained from the Central Statistical Agency, Ethiopia. While all surveys were used for[9, 18-20], only the 2011 & 2016 EDHS datasets were used to fit the cox-proportional hazard models in the multivariate analysis, since health-related variables such as postnatal care visits and delivery complications were collected in these survey years only.

Mothers who have had at least one child in their life-time are considered in this analysis. Survival information was obtained from 21,170 mothers who have at least one live births child in their life time. The analyses used the most recent birth because only those births had detailed information about the use of perinatal health services.

Study Outcomes

The main outcomes used were childhood mortality in three different time periods. The time periods were neonatal death (death after birth through 30 days of life), infant death defined as death of an infant from 0 to 11 months of life, and death of children defined as death of a child after birth through 59 months of life.

Potential risk factors

The Mosley and Chen [21] framework of factors influencing child survival in developing countries was the basis for selecting potential risk factors for childhood mortality. The outcome variables were examined against all selected potential risk variables and these variables were organized into four distinct groups: community, household, individual and health services factors.

The community level factors assessed were residence type and geographical zone. The residence type was categorized into two groups (urban and rural) and geographical zone covered Tigray, Afar, Amhara, Oromia, Somali, Benishangul-Gumuz, Southern Nations Nationalities and People Region (SNNPR), Gambella and Harari, Dire Dawa and Addis Ababa. The household factor used were based on water source for drinking. The data for water source is classified into improved and unimproved water sources. Under the improved water sources, we included (piped water/bottled water); and unimproved water sources were also classified in to two (rain/well/surface water) and (river/stream/lake and spring)

The individual level factors consisted of maternal, child and paternal characteristics: maternal factors were number children ever born, education, age, contraceptive use; child factors were sex of the baby, combined birth place and mode of delivery, delivery assistance, and a combination of birth order and birth interval. The health services factors were: the presence of delivery complications, the desire for previous pregnancies, contraceptive use, number of antenatal clinic visits, postnatal visits within two months after delivery and number of tetanus toxoid (TT) vaccinations during pregnancy.

Analysis

The Cox proportional hazards model was used to explore the relationship between the dependent variable and community, household, individual and health services factors. The Cox proportional hazards model (survival analysis) is appropriate when analyzing non-censored and censored observations. For the dependent variable in the analyses, the children's survival status was combined with the age at death in months (if the child had died) or the last month the child was known to be alive (if the child was still living at the time of the survey). Children known to have died before 60 months of age (i.e. non-censored) were regarded as cases, while children who were still alive at the time of the survey were treated as right-censored observations. The probability of childhood death is regarded as the hazard. The hazard was modeled using the following equations:

$$H(t)=H_0(t)\exp.(b_1x_1+b_2x_2+b_3x_3+...+b_kx_k \quad .....(1),$$

Where $X_1 \ldots X_k$ are a collection of explanatory variables and $H_0(t)$ is the baseline hazard at time t, representing the hazard for a person with the value 0 for all the explanatory variables.
However, by dividing both sides of equation 1 by $H_0(t)$ and taking logarithms, it becomes:

$$\ln (H(t)/H_0(t)) = b_1x_1+b_2x_2+b_3x_3+...+b_kx_k \quad .....(2),$$

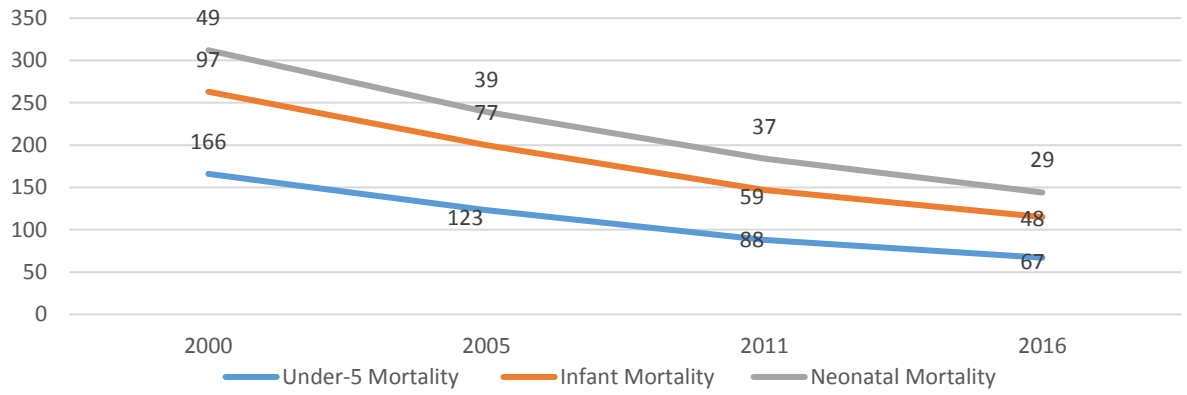
Where $H(t)/H_0(t)$is regarded as the hazard ratio. The coefficients $b_i...b_k$ are estimated by Cox regression. Four models were fitted at the multivariate level of analysis. Model 1 presents the univariate hazard ratios (i.e. unadjusted hazard ratios), while Models 2 to 4 present the multivariate or adjusted hazard ratios. Measures of association between the outcome variable and explanatory variables were expressed as hazard ratios (HR) and 95% confidence interval. All analyses were done using R (version 3.4.3).

Results

The percentage of neonatal deaths out of all under-5 deaths was 67‰ in 2016, 88‰ in 2011, 123‰ in 2005, and 166‰ in 2000. Figure 1 shows the rates of neonatal, post- neonatal, infant, child and under-5 mortality rates over time. There was a steady decline in mortality rates from 2000 through to 2016, although the decline of neonatal, infant and under-5 mortality was not statistically significant.

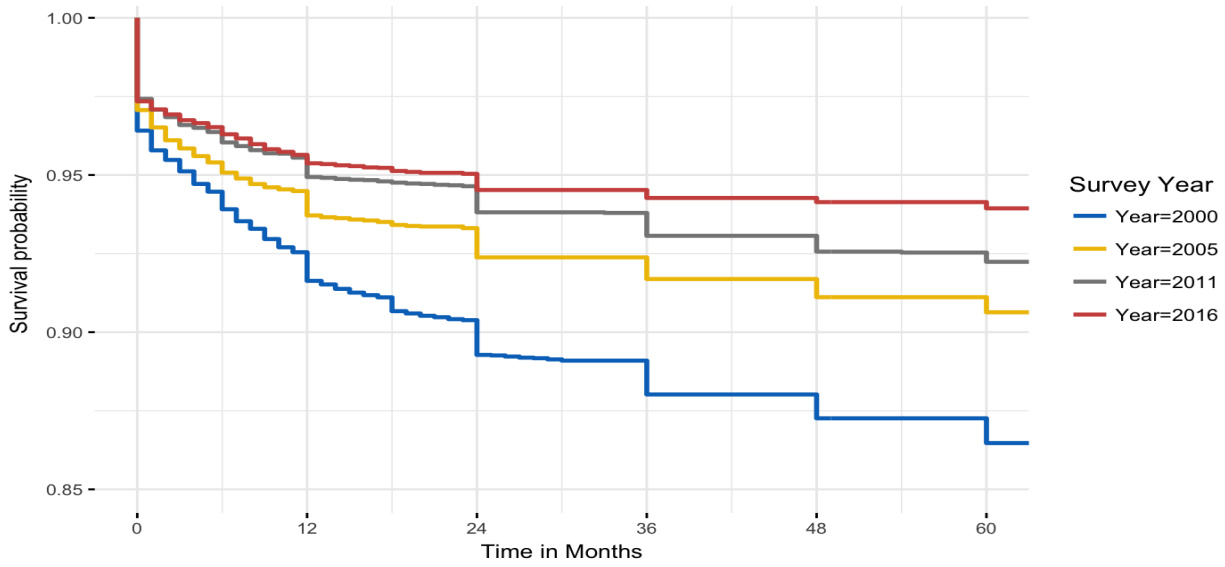
Figure 1: Neonatal, Infant and Under-5 Mortality by Survey Year (EDHS 2000— 2016)

(Deaths per 1000 live births in the 5-year period before the survey)



A Kaplan Meier estimation indicates that most child death occurred at the earlier months and then gradually declined as the age child advanced to 60 months (Figure 1). The probability of survivorship for children under-5 years of age increased over the past sixteen years (2000 – 2016)

Figure 2: Kaplan-Meier function of Over All under-5 mortality of child in Ethiopia



Multivariate analysis of risk factors for under-5 mortality

The Cox-proportional hazard model was fitted to find factors affecting under-5 mortality in Ethiopia. The results of the multivariate analysis of risk factors for neonatal, infant mortality and under-5 mortality in Ethiopia are shown in the table 1 below. While fitting the cox-proportional hazard model we considered only the EDHS 2011 & 2016 datasets, since health-related variables such as postnatal care visits and delivery complications were collected in these survey years only. *After controlling for health services factors the geographical and socio-economic factors such as region, place of residence, education, occupation and wealth index were no longer significantly associated with under-5 mortality, infant mortality and neonatal mortality* (see table 1 and table 2).

Neonatal Mortality

As shown in table 1, there was a reduction in the hazard of neonatal deaths in 2016 compared with 2011. Male neonates were significantly more likely to die than female neonates in the first 30 days

of life (hazard ratio (HR) =1.73, CI: [1.35, 2.25] for male neonates). Neonates who were born in health facilities without a cesarean session are significantly more likely (HR=2.46; CI: [1.16, 5.43]) to die than others who were born in health facilities with a cesarean session. There was significantly higher hazard of dying (HR=2.28; CI: [1.16 to 4.50]) among neonates who never receive postnatal care two months after delivery than others who receive postnatal check within two months. A decreased risk of post neonatal death was associated with mothers among mothers aged 25-34 than those aged 15-24, those who had two or more TT vaccinations during pregnancy, and those who use any contraceptives.

Infant Mortality

The hazard of infant mortality in 2016 did not show a decrease compared with 2011. Male infants were significantly more likely to die than female infants in the first one year of life (hazard ratio (HR)=1.70, CI: [1.29, 2.23] for male neonates). Infants whose mothers were widowed/divorced/separated were at higher risk dying than those whose mothers were married/in union. Infants born in fifth or above birth rank have significantly higher risk of dying than those first-born infants. Infants who were born in health facilities without a cesarean session have higher risk of dying than others who were born in health facilities with a cesarean session. There was a significantly higher hazard of dying among infants who never receive postnatal care within two months after delivery than others who receive postnatal check within two months. Infants whose mothers used rain/well/surface water have a higher risk of dying than those whose mothers used piped water. Other factors that significantly reduced the risk of infant mortality include infants who had two or more TT vaccinations, who used any contraceptives and infants who have older mothers (aged 20 and above) (see table 1).

Child Mortality

Hazard ratios revealed that mother's age, maternal marital status, previous death of a sibling, sex of a child, combined birth rank and interval, contraceptive use, postnatal check within two months after deliver and water source, were all common factors associated with under-5 mortality.

As shown in table 2, the hazard of child mortality between 2011 and 2016 were similar. The factors that significantly reduced the risk of under-5 mortality include children who had two or more TT vaccinations, who used any contraceptives and under-5 children who have older mothers (aged 20 and above), children who received postnatal care two months after delivery and mothers who used piped water for drinking. The risk of child deaths was higher in children whose mothers had been formerly married, male children, fourth rank children with an interval of ≤2 years and fifth or more rank children, children born in health facilities without a caesarean session (see table 2).

Figure 5: Kaplan-Meier Survival function of under-5 mortality by postnatal care check two months after delivery (EDHS 2011 & 2016*)*

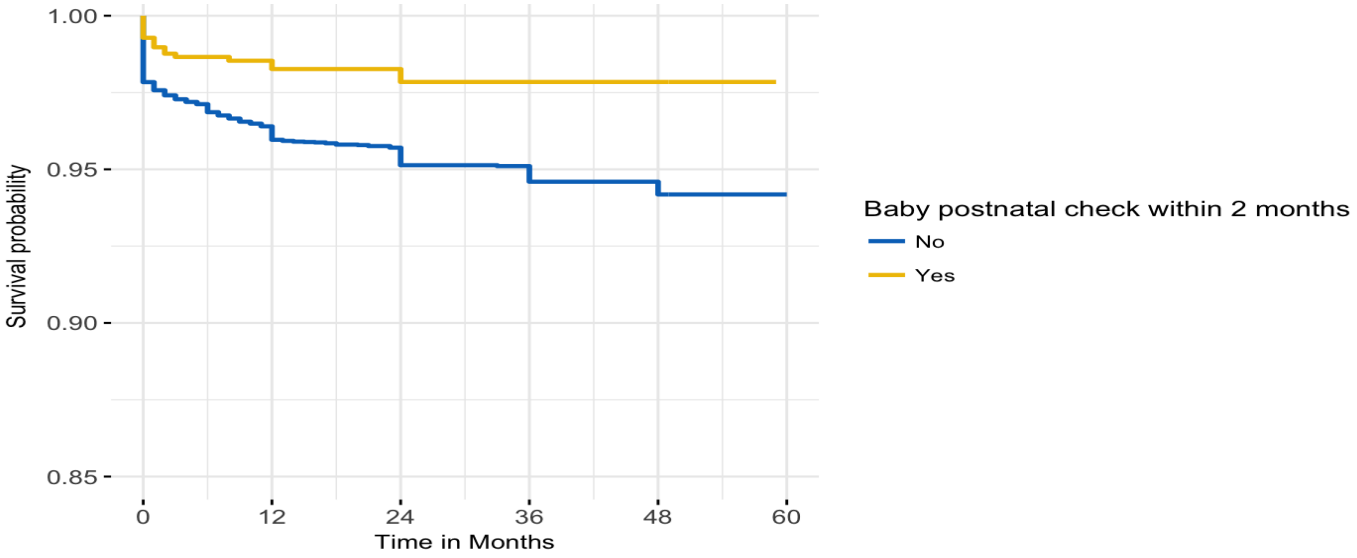


Figure 6: Kaplan-Meier Survival function of under-5 mortality by place of residence

(EDHS 2011 & 2016)

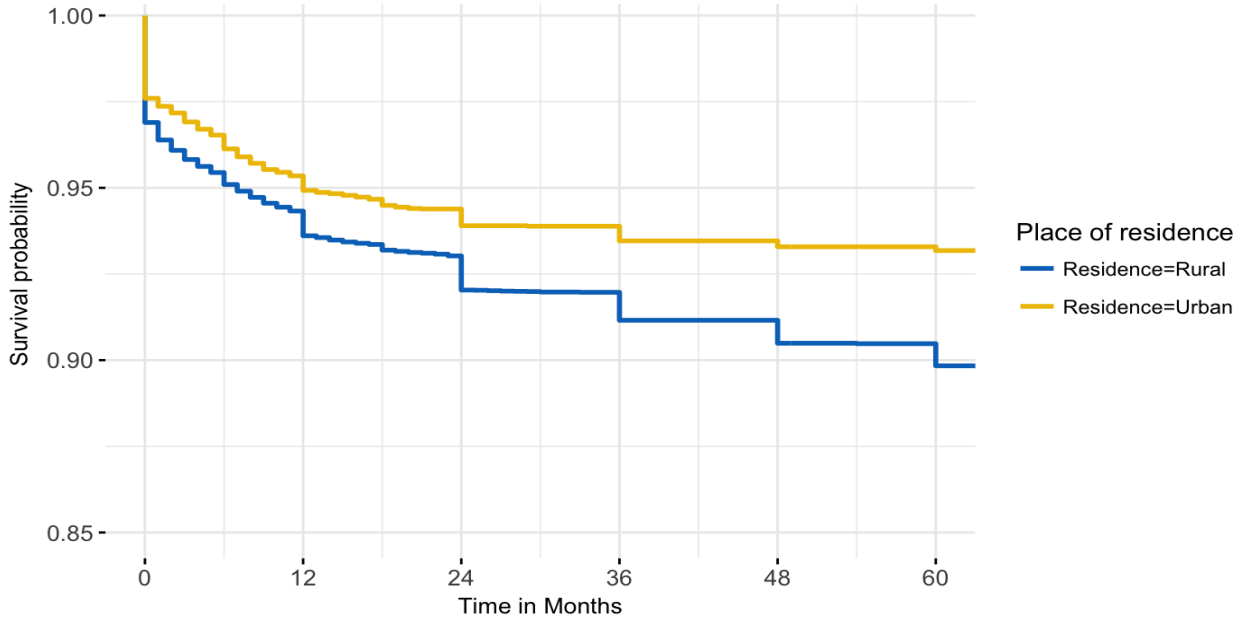


Figure 7: Kaplan-Meier Survival function of under-5 by combined Place and Mode of Delivery

(EDHS 2011 & 2016)

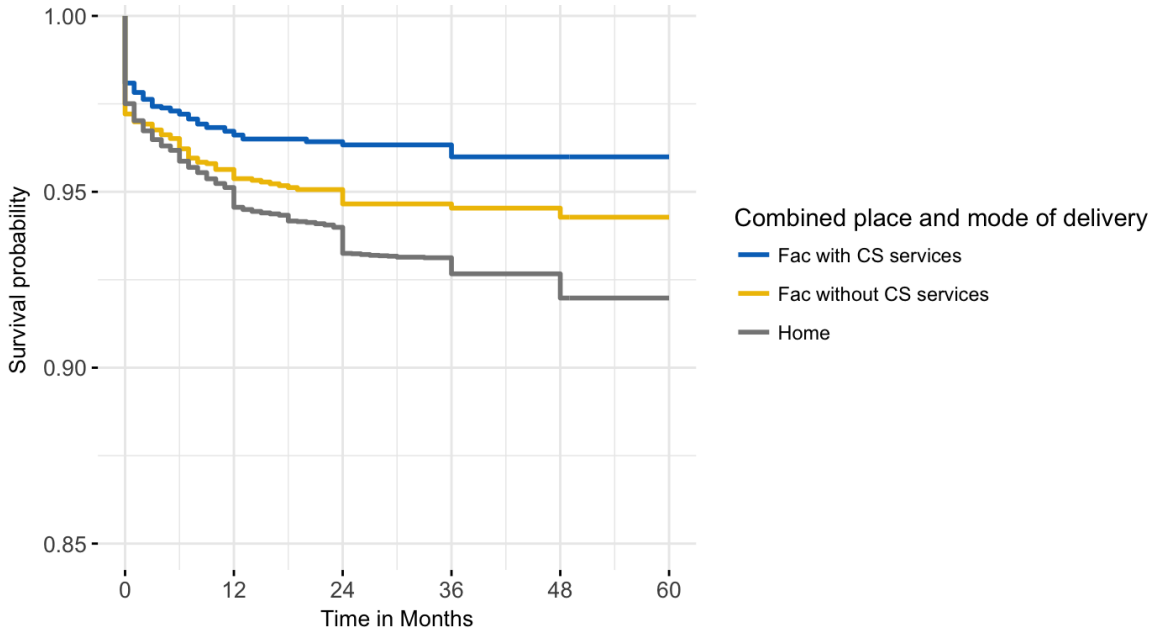


Figure 8: Kaplan-Meier Survival function of under-5 Morality by Water Source (EDHS 2011 & 2016)

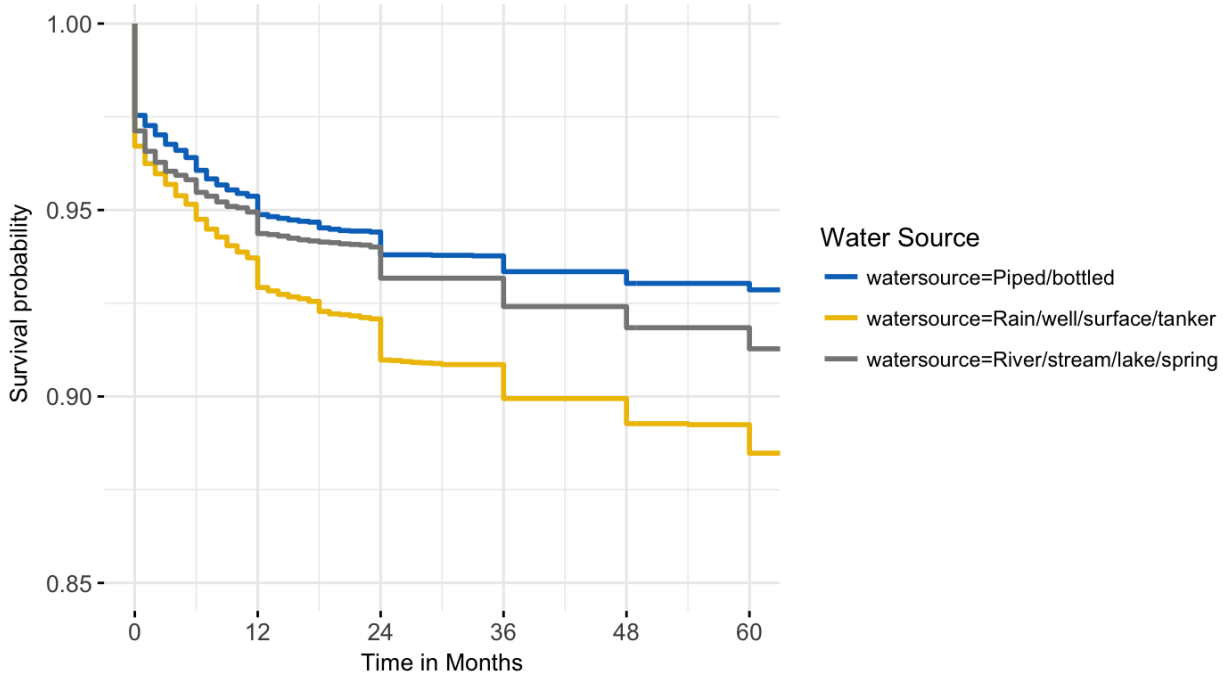


Table 1: Hazard ratio estimates for determinants of Neonatal and Infant Mortality in Ethiopia

	Neonatal Mortality (0-30 days)				Infant Mortality (0-1 Year)			
	Hazard	95% CI			Hazard	95% CI		
Characterstics	Ratio	Lower	Upper	P-value	Ratio	Lower	Upper	P-value
Year (Ref:2011)								
2016	1.02	0.96	1.08	0.55	0.99	0.93	1.06	0.745
Mother's age at first birth (Ref: <20)								
20+	---	---	---	---	0.85	0.62	1.17	0.314
Maternal highest level of education (Ref:No education)								
Primary	1.14	0.85	1.54	0.38	1.19	0.88	1.61	0.249
Secodary and Higher	0.63	0.23	1.70	0.36	0.82	0.28	2.45	0.723
Marital status (Ref:Marrried or In Union)								
Never married	---	---	---	---	0.40	0.11	1.50	0.174
Widowed/divorced/separated	---	---	---	---	1.64	1.03	2.63	0.04*
Sex of a child (Ref: Female)								
Male	1.73	1.33	2.25	0.00***	1.67	1.27	2.19	0.00***
TT pregnancy times (Ref:Never)								
One TT	1.14	0.71	1.82	0.58	1.24	0.77	2.02	0.380
2+TT	0.68	0.48	0.97	0.04*	0.68	0.47	0.98	0.04*
Contraceptive use (Ref: Yes)								
No	1.59	1.12	2.26	0.01**	1.47	1.00	2.15	0.05*
Antenatal care (Ref: Yes)								
No	1.04	0.75	1.45	0.82	0.97	0.68	1.39	0.858
Postnatal care (Ref: Yes)								
No	2.30	1.17	4.54	0.02*	2.06	1.01	4.19	0.047*
Birth rank and birth interval (Ref: 1st Birth Order)								
2nd/3rd birth rank, <=2 years	1.04	0.54	1.98	0.91	0.94	0.46	1.92	0.867
2nd/3rd birth rank, >2 years	0.96	0.54	1.71	0.90	0.94	0.51	1.73	0.843
4+ birth order	0.58	0.26	1.31	0.19	0.50	0.22	1.14	0.102
Combined place and mode of delivery (Ref: Health facilities with caesarean)								
Health facilities with out caesarean	2.46	1.16	5.23	0.02*	2.41	1.03	5.62	0.042*
Home	1.46	0.84	2.54	0.18	1.36	0.73	2.52	0.333
Previous death of sibling (Ref: Alive)								
Dead	1.24	0.92	1.66	0.16	1.14	0.84	1.54	0.410
Residence (Ref: Rural)								
Urban	---	---	---	---	1.29	0.75	2.23	0.353
Water source (Ref: Piped Water)								
Rain/well/surfacewater	---	---	---	---	1.64	1.00	2.71	0.05*
River/stream/lake/spring	---	---	---	---	1.38	0.88	2.17	0.158
Parity (Ref: 1-2)								
3-4	1.37	0.82	2.28	0.23	1.35	0.78	2.33	0.285
5+	2.24	1.09	4.59	0.03*	2.45	1.16	5.17	0.02*
Region (Ref: Addis Ababa)								
Afar	---	---	---	---	1.74	0.64	4.77	0.279
Amhara	---	---	---	---	1.41	0.51	3.92	0.512
Ben-Gumuz	---	---	---	---	1.06	0.38	2.95	0.912
Dire Dawa	---	---	---	---	1.72	0.64	4.59	0.278
Gambella	---	---	---	---	1.26	0.46	3.42	0.651
Harari	---	---	---	---	1.24	0.46	3.35	0.675
Oromia	---	---	---	---	1.71	0.62	4.67	0.299
SNNP	---	---	---	---	1.72	0.64	4.63	0.285
Somali	---	---	---	---	1.48	0.55	3.99	0.436
Tigray	---	---	---	---	1.17	0.43	3.15	0.759

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 2: Hazard ratio estimates for determinants of Child Mortality in Ethiopia

		95% CI		
	Hazard Ratio	Lower	Upper	P-value
Year (Ref:2011)				
2016	1.00	1.00	0.94	1.06
Mother's age at first birth (Ref: <20)				
20+	0.79	0.59	1.06	0.11
Maternal highest level of education (Ref:No education)				
Primary	1.17	0.87	1.57	0.30
Secodary and Higher	0.76	0.26	2.26	0.63
Marital status (Ref:Marrried or In Union)				
Never married	0.36	0.10	1.36	0.13
Widowed/divorced/separated	1.74	1.14	2.66	0.01*
Sex of a child (Ref: Female)				
Male	1.60	1.24	2.05	0.00***
TT pregnancy times (Ref:Never)				
One TT	1.17	0.73	1.88	0.51
2+TT	0.72	0.52	1.01	0.05*
Contraceptive use (Ref: Yes)				
No	1.49	1.04	2.16	0.031*
Antenatal care (Ref: Yes)				
No	1.04	0.75	1.44	0.82
Postnatal care (Ref: Yes)				
No	2.06	1.01	4.19	0.047*
Birth rank and birth interval (Ref: 1st Birth Order)				
2nd/3rd birth rank, <=2 years	0.80	0.39	1.64	0.54
2nd/3rd birth rank, >2 years	0.85	0.46	1.55	0.59
4+ birth order	0.61	0.29	1.29	0.19
Combined place and mode of delivery (Ref: Health facilities with caesarean)				
Health facilities with out caesarean	2.38	1.02	5.55	0.04*
Home	1.47	0.80	2.68	0.21
Previous death of sibling (Ref: Alive)				
Dead	1.14	0.85	1.52	0.38
Residence (Ref: Rural)				
Urban	1.29	0.75	2.23	0.35
Water source (Ref: Piped Water)				
Rain/well/surfacewater	1.64	1.00	2.71	0.05*
River/stream/lake/spring	1.38	0.88	2.17	0.16
Parity (Ref: 1-2)				
3-4	1.35	0.78	2.33	0.28
5+	2.45	1.16	5.17	0.02*
Region (Ref: Addis Ababa)				
Afar	1.74	0.64	4.77	0.28
Amhara	1.41	0.51	3.92	0.51
Ben-Gumuz	1.06	0.38	2.95	0.91
Dire Dawa	1.72	0.64	4.59	0.28
Gambella	1.26	0.46	3.42	0.65
Harari	1.24	0.46	3.35	0.67
Oromia	1.71	0.62	4.67	0.30
SNNP	1.72	0.64	4.63	0.29
Somali	1.48	0.55	3.99	0.44
Tigray	1.17	0.43	3.15	0.76

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Discussion

Around the world, an estimated 7,000 newborn babies die every day. More than 80 per cent of those deaths are the result of causes that could have been prevented with basic solutions such as affordable, quality health care delivered by well-trained doctors, nurses and midwives, antenatal and postnatal nutrition for mother and baby, and clean water [22].

Substantial global progress has been made in reducing child deaths since 1990. The total number of under-5 deaths worldwide has declined from 12.6 million in 1990 to 5.6 million in 2016 – 15,000 every day compared with 35,000 in 1990 [1]. This global decline is reflected in this study. We found a steady decline in the rates of neonatal, infant and under-5 mortality in Ethiopia between 2000 and 2016.

In this study the covariates age, marital status, TT vaccination during pregnancy, children ever born, sex of a child, combined place and mode of delivery, post-natal care visits two months after delivery were found to be significantly associated with under-5 mortality. When health-related variables are incorporated in the model the geographical and socio-economic factors such as region, type of place of residence, education, occupation and wealth index variables were no longer significantly associated with under-5 mortality, infant mortality and neonatal mortality. This implies that special attention should be given to health-related and demographic factors.

Our study showed that male neonates had a significantly higher risk of dying during the neonatal period compared with female neonates. This finding is consistent with a cross-sectional study conducted in Indonesia, Nigeria and Bangladesh 2015 [16, 23]. An increased risk of dying in the

first month of life among male neonates may be because of high vulnerability to infectious disease[24]. Female neonates are more likely to develop early fetal lung maturity in the first week of life[25], which may result in a lower incidence of respiratory diseases in female compared with male neonates.

Our study was limited in a number of ways. First, the survey interviewed only surviving women, and this may have led to an underestimation of mortality rates because of the association between neonatal and maternal deaths. Second, there may be other possible determinants that were not available in the various versions of the EDHS datasets, such as environmental and genetic factors, or that were only available for the most recent delivery of a mother who did not give birth within 5 years preceding the surveys. Third, reverse causality is common with cross-sectional data, such as those from the DHS. For instance, under-5 mortality may be a factor for using contraceptive use, post-natal care visits and combined mode of delivery, which was not observed in the current study.

Neonatal tetanus remains an important and preventable cause of neonatal mortality globally[26]. This finding is consistent with a cross-sectional study conducted in Bangladesh in 2015[16]. Immunization of pregnant women or women of childbearing age with at least two doses of TT is estimated to reduce mortality from neonatal tetanus by 94%[26]. In our study, we found that infants whose mothers did not have TT immunizations had significantly higher odds of neonatal, infant and child mortality. The association of TT immunizations with neonatal, infant and child mortality may be due more to its association with education and socioeconomic status than with a direct effect of the vaccine.

We also found that there was a lower under-5 mortality rate in children who were delivered in health facilities without a CS session. Past studies have associated high mortality rates to home delivery of babies[27]. This is mostly associated with delivery complications. Health facilities with a CS session is very scarce in Ethiopia. The key challenges might be related to transportation and availability of obstetric services were addressed by an ongoing project, giving a unique opportunity to understand why women might continue to prefer home delivery even when facility based delivery is available at minimal cost [28]. In developing countries, women reported poor quality of care and previous negative experiences with health facilities. In addition, this might be related to women's low awareness on the advantages of skilled attendance at delivery, little role in making decisions (even when they want), and economic constraints during referral that contribute to neonatal, infant and child mortality.

Birth control is said to be driven by contraceptive use and other factors. Recent studies conducted in Ethiopia and Bangladesh have found favorable effects of contraceptive use in reducing neonatal, infant, and under-5 mortality [16, 29]. We found in our study that infants whose mothers did not use any contraceptives had significantly higher odds of neonatal, infant, child and under-5 mortality.

Divorced/separated and widowed women were found to be significantly more likely to experience child death than their married/in union counterparts. Even though many studies have not yet been conducted on the effect of mother's marital status on child mortality, it is evident that mothers in stable marriage would get support from partners during antenatal through postnatal care. On the contrary single mothers (divorced/separated and widowed) are mostly live by in a very limited income to secure the daily food consumption of the household and to take care of their children[30]. Also, marriage may confer advantages such as pooling of resources to either

patronize good health services or provide adequate care with respect to providing good nutrition to infants and children [31].

In our study, the probability of surviving among women who went for postnatal care checkups was found to be higher than those who never checked never postnatal care services in the past two months (figure 5). Mothers who never went to post-natal care two months after delivery are found to be significantly more likely to experience neonatal, infant and under-5 mortality than their counter parts went to health care services for post-natal checkups. Mothers who performed postnatal home visits within the first 2 days after birth by skilled healthcare workers also hada lower likelihood of child death[32]. We also found that infants whose mothers did not have TT immunizations had significantly higher hazard child mortality. Immunization of pregnant women or women of childbearing age with at least two doses of TT is estimated to reduce mortality from neonatal tetanus by 94% [26].

Mortality risk of a child increases as size of children ever born increases. The hazard of neonatal, infant and under-5 deaths increased significantly among mothers who had born more than five children. Similar findings obtained in Ethiopia show a positive relationship between family size and child mortality[12, 33]. This might be related to low access and motivation to receive professionally assisted delivery services as number of children increases. Women with two or more children aged less than five years were 40% less likely to receive professionally-assisted delivery services compared to women with only one child[34]. Another possible explanation is that women with low-parity have relatively higher socioeconomic status that motivate and give them access them to deliver in medical facilities with CS services than their corresponding counterparts with lower parity.

Access to clean water is considered to be one of the important factors that contributed to more than 80 percent of children deaths in the world [22]. This global effect of clean water on child mortality is reflected in this study. The use of unimproved source of drinking water were found to be associated with increased risk of neonatal, infant and child mortality. There is also a considerable evidence from developing country studies that indicate that household sanitation and a clean water supply for promote child health and survival [35-37]. In Ethiopia, the proportion of population using improved drinking-water sources is only 57%, and those who use improved sanitation is less than five percent[3]. Therefore, implementing a cost-effective public health-related intervention to improve household environmental conditions, such as access to improved source of drinking water might have a positive impact on reducing infant and child mortality.

Conclusion:

The total number of under-5 deaths worldwide has declined from 12.6 million in 1990 to 5.6 million in 2016. Ethiopia is still among five countries which account for half of the global under-5 deaths [2]. The combined 2005 and 2011 EDHS data sets examined in this study showed that the covariates age, marital status, postnatal care visits two months after delivery, TT vaccination during pregnancy, children ever born, sex of a child, combined place and mode of delivery, post-natal care visits two months after delivery were found to be significantly associated with under-5 mortality. Our findings indicate that the need to expand and improve quality of health care services as well the importance of community based intervention. Educating health extension workers and traditional birth attendants about TT vaccinations, contraceptive use and postnatal care visits two months after delivery is critical to reduce neonatal, infant and under-5 mortality. Findings from

this study could also help provide a framework to design future health plans and policies towards achieving effective health initiatives to enhance child survival.

References

1. (GHO), G.H.O., *Under-five mortality.* 2017.
2. UNCEF, *Levels and Trends in Child Mortality: Report 2017*. 2017, SAVE THE CHILDREN.
3. WHO, *World Health Statistics.* 2017.
4. Rutherford, M.E., K. Mulholland, and P.C. Hill, *How access to health care relates to under-five mortality in sub-Saharan Africa: systematic review.* Tropical medicine & international health, 2010. **15**(5): p. 508-519.
5. Issaka, A.I., K.E. Agho, and A.M. Renzaho, *The impact of internal migration on under-five mortality in 27 sub-Saharan African countries.* PloS one, 2016. **11**(10): p. e0163179.
6. Hug, L., et al., *United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), 'Levels & Trends in Child Mortality: Report 2017, Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation.* 2017.
7. MoH, F., *National Strategy for child survival in Ethiopia.* Addis Ababa, Ethiopia, 2015.
8. You, D., et al., *Global, regional, and national levels and trends in under-5 mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Inter-agency Group for Child Mortality Estimation.* The Lancet, 2015. **386**(10010): p. 2275-2286.
9. CSA and I. ICF, *Ethiopia Demographic and Health Survey 2016.* Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ICF International, 2016.
10. Deribew, A., et al., *Trends, causes, and risk factors of mortality among children under 5 in Ethiopia, 1990–2013: findings from the Global Burden of Disease Study 2013.* Population health metrics, 2016. **14**(1): p. 42.
11. Ayele, D.G. and T.T. Zewotir, *Childhood mortality spatial distribution in Ethiopia.* Journal of Applied Statistics, 2016. **43**(15): p. 2813-2828.
12. Ayele, D.G., T.T. Zewotir, and H. Mwambi, *Survival analysis of under-five mortality using Cox and frailty models in Ethiopia.* Journal of Health, Population and Nutrition, 2017. **36**(1): p. 25.
13. Ayele, D.G. and T.T. Zewotir, *Comparison of under-five mortality for 2000, 2005 and 2011 surveys in Ethiopia.* BMC public health, 2016. **16**(1): p. 930.
14. Negera, A., et al., *An analysis of the trends, differentials and key proximate determinants of infant and under-five mortality in Ethiopia.* ICF International: Calverton, Maryland USA, 2013.
15. Ettarh, R. and J. Kimani, *Determinants of under-five mortality in rural and urban Kenya.* Rural Remote Health, 2012. **12**: p. 1812.
16. Abir, T., et al., *Risk factors for under-5 mortality: evidence from Bangladesh Demographic and Health Survey, 2004–2011.* BMJ open, 2015. **5**(8): p. e006722.
17. CSA, I., *Ethiopia Demographic and Health Survey 2016.* 2016.
18. CSA and O. Macro, *Ethiopia demographic and health survey 2000.* Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ORC Macro. , 2001.
19. CSA and O. Macro, *Ethiopia demographic and health survey 2005.* Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ORC Macro., 2006.
20. CSA and I. ICF, *Ethiopia demographic and health survey 2011.* Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ICF International, 2012. **430**.
21. Mosley, W.H. and L.C. Chen, *An analytical framework for the study of child survival in developing countries.* Population and development review, 1984. **10**: p. 25-45.
22. UNICEF, *Every Child Alive: The urgent need to end newborn deaths.* 2017.
23. Uthman, O.A. and O. Aremu, *Malnutrition among women in sub-Saharan Africa: rural-urban disparity.* Rural and Remote Health, 2008. **8**(2).

24. Alonso, V., V. Fuster, and F. Luna, *Causes of neonatal mortality in Spain (1975–98): influence of sex, rural–urban residence and age at death.* Journal of Biosocial Science, 2006. **38**(4): p. 537-551.
25. Khoury, M.J., et al., *Factors affecting the sex differential in neonatal mortality: the role of respiratory distress syndrome.* American journal of obstetrics and gynecology, 1985. **151**(6): p. 777-782.
26. Blencowe, H., et al., *Tetanus toxoid immunization to reduce mortality from neonatal tetanus.* International Journal of epidemiology, 2010. **39**(suppl_1): p. i102-i109.
27. Filippi, V., et al., *Maternal health in poor countries: the broader context and a call for action.* The Lancet, 2006. **368**(9546): p. 1535-1541.
28. Shiferaw, S., et al., *Why do women prefer home births in Ethiopia?* BMC pregnancy and childbirth, 2013. **13**(1): p. 5.
29. van Soest, A. and U. Saha, *Does family planning reduce infant mortality? Evidence from surveillance data in Matlab, Bangladesh.* 2012.
30. Bitew, F.H. and D.S. Telake, *Undernutrition among women in Ethiopia: rural-urban disparity.* 2010.
31. Kanmiki, E.W., et al., *Socio-economic and demographic determinants of under-five mortality in rural northern Ghana.* BMC international health and human rights, 2014. **14**(1): p. 24.
32. Baqui, A.H., et al., *Effect of timing of first postnatal care home visit on neonatal mortality in Bangladesh: a observational cohort study.* Bmj, 2009. **339**: p. b2826.
33. Bereka, S.G. and F.G. Habtewold, *Under-Five Mortality of Children and its Determinants in Ethiopian Somali Regional State, Eastern Ethiopia.* Health Science Journal, 2017. **11**(3).
34. Mekonnen, Y. and A. Mekonnen, *Factors influencing the use of maternal healthcare services in Ethiopia.* Journal of health, population and nutrition, 2003: p. 374-382.
35. Sastry, N., *What explains rural-urban differentials in child mortality in Brazil?* Social science & medicine, 1997. **44**(7): p. 989-1002.
36. Ezeh, O.K., et al., *The impact of water and sanitation on childhood mortality in Nigeria: evidence from demographic and health surveys, 2003–2013.* International Journal of Environmental Research and Public Health, 2014. **11**(9): p. 9256-9272.
37. Mugo, N.S., et al., *Determinants of neonatal, infant and under-five mortality in a war-affected country: analysis of the 2010 Household Health Survey in South Sudan.* BMJ Global Health, 2018. **3**(1): p. e000510.