Under five mortality and its predictors in Gilgel Gibe Health and Demographic Surveillance System Site, South West Ethiopia

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Abstract

Background: In spite of global decline in under-five mortality, the goal of achieving MDG 4 still remains largely unattained in low and middle income countries as the year 2015 closes-in. To accelerate the pace of mortality decline, proven interventions with high impact need to be implemented. This paper estimates mortality rates and identify potential predictors of under-five mortality.

Methods: Data for this analysis is extracted from the Gilgel Gibe Health and Demographic Surveillance System database that employed an open-cohort design with biannual population update through the registration of birth, death and migration. Total of 5,446 live births from 2006 to 2008 were included for the analysis with a maximum follow-up period of five years. The Kaplan and Meier method was used to estimate mortality rates and the Cox proportional hazards model was used to identify predictors of under-five mortality.

Results: During the follow-up period 554 children died before celebrating the fifth birth day that gave an under-five mortality rate of 104.2 per 1000 person years with neonatal and infant mortality rates of 44.8 and 75.6 per 1000 person years. Among the household, individual and residence variables considered as potential factors, rural residents, households with no toilet facility and soap in the house, older mothers (30-34 & 35+ years old compared with 25-29 year olds), multiple births and being boy had a significantly higher risk of death throughout the observation period compared to their counterparts.

Conclusion and recommendation: The rates of infant and under five mortalities remained high in the surveillance population. Emphasis should be given for rural children as they are mostly at disadvantage in terms of health services and others than that of urban. In addition, as sanitation is the most important factor for the reduction of the main killers of children like diarrhoeal diseases, households should be encouraged and supported to construct toilet facilities that include pit latrines and have soap in the house for keeping personal hygiene of children and other family members.

Key: Live birth, under-five mortality, magnitude, determinants, Gilgel Gibe HDSS, Ethiopia

Introduction

The Millennium Development Goals (MDGs) represent the widest commitment in history to addressing global poverty and ill health (1). The fourth goal (MDG-4) commits the international community to reducing mortality in children aged younger than 5 years by two-thirds between 1990 and 2015. Between 1960 and 1990, the risk of dying in the first 5 years of life was halved—a major achievement in child health (2).

Of the estimated 130 million infants born each year globally, 4 million die in the first 28 days of life. Three-quarters of neonatal deaths occur in the first week, and more than one-quarter occur in the first 24 hours. In addition, newborn, or neonatal, deaths account for 40% of all deaths among children under five worldwide, where the vast majority of infant deaths take place in developing countries (3, 4).

Although the decline in infant mortality rates in Ethiopia is encouraging, still nearly six in a hundred infants die before the age of one. One in every 17 Ethiopian children dies before the first birthday, and one in every 11 children dies before the fifth birthday. The neonatal mortality rate was 37 deaths per 1,000 live births. Infant mortality declined by 39 percent between the 2000 and the 2011 EDHS, from 97 to 59 deaths per 1,000 live births. Under-five mortality has declined by 47 percent over the same period; from 166 deaths per 1,000 live births to 88 deaths per 1,000 live births. Programs to upgrade the status of women through education and enhanced participation in the labour force can help to improve the probability of survival of young children (5).

Mother's education and wealth index emerge as powerful background covariates of under-five mortality in the EAG states, India, for the reason that both are known to be associated with better child care practices. The hazard ratio was 1.41 (95% CI=1.14−1.75) for children born to mothers aged 12-19 years compared to mothers aged 20-30 years (6).

The Gilgel Gibe Health and Demographic Surveillance System site was established in September 2005 surrounding the Gilgel Gibe Hydroelectric dam found in Jimma Zone, Oromia Region, Southwest Ethiopia. In the surveillance site, data on pregnancies, pregnancy outcomes, death, migration and marital change are collected regularly to update the population statistics.

Currently, the surveillance population is about 60,000 (70% rural) and characterized by high fertility, mortality and migration rates. Over the 2005-2010 surveillance period with about 300,000 person years of observation, the birth, death, in and out-migration rates were 37.4, 8.4, 20.3 and 23.4 per 1000 person years respectively (7). There was no detailed analysis done for the different event indicators including mortality. This lack of more in-depth analysis leads to the major aims of this study. The main objective of this analysis is therefore, to determine mortality rates during the first five years of life and identify potential predictors of under-five mortality in Gilgel Gibe Health and Demographic Surveillance System Site.

Methods

Data for this analysis is extracted from the Gilgel Gibe Health and Demographic Surveillance System that employed an open-cohort design with biannual population update through the registration of birth, death and migration. In addition, household characteristics including household assets, monthly income, water, latrine and others were collected during the baseline and re-census times as well as in add on surveys.

All live births (N=5,446) registered from 2006 to 2008 were recruited and followed for up to five years, or early death or moved out from the surveillance area with the last observation date being the end of 2013.

Survival time from birth to death, or lost for follow-up, or 1824 days for survivors with death of a child before celebrating the fifth year birth day used as event of interest

Residence, household socio-economic status based on reported monthly income, years of education of the mother, number of children ever born, number of birth for the index child (single or multiple), source of drinking water (protected or unprotected), presence of latrine facility and presence of soap in the house at the time of the interview. The monthly household income was classified into three groups labeling households as poor, average and rich. Sex of the child and age of the mother at delivery were also included.

Description of the study subjects and mortality rates were presented by the different individual, household and community level factors. Tables and graphs were used to present the findings.

The Kaplan and Meier method was used to determine cumulative survival probabilities their by mortality rates at early neonatal, neonatal, infant and under-five age and the traditional Cox proportional hazards model was used to identify potential determinants of under-five mortality.

Cox Proportional Hazards model is written as: $h(t) = h_o(t)\exp(\beta X_i), t > 0$

Where, $h_0(t)$ is an unspecified baseline hazard function and β denote the vector of the true regression coefficients for covariates X_i, (i=1, 2, ..., p). We could obtain an estimator $\hat{\beta}$ of β based on the working assumption that the under-five deaths in each family were independent of one another.

Results

For this analysis a total of 5,446 live births registered from 2006 to 2008 were included and followed for up to five years, early death or lost for follow up, resulting in 554 (10.2%) deaths and 178 moved out of the surveillance area.

The distribution of the study subjects by different socio-demographic characteristics showed that 16.8% of the births were from urban area and mother whose age was < 20 (12.9%) and 35 and above (11.3%) and 81.5% of the mother had no formal education. With respect to type, 2.0% of the births were from a multiple (two or more) birth and on number of children ever born by index mothers, 13.9% of the mothers had only one (primipara) and 38.6% had 5 or more live births (multiparous). (table 1). Concerning water and sanitation, 77.5% of the households used drinking water from unprotected water source that include river, pond, well and unprotected spring, 33.5% had no any latrine facility and 45.8% had no soap in the house at the time of the interview (table 2).

Relatively higher percent of deaths was observed among rural residents, boys, children born from older mothers, those who had no education, poor families, babies from multiple births and multiparous mother (5+). In addition, children from families who used unprotected drinking water source, with no latrine facility and those who had no soap in the house were observed to have high percent of under-five child death (tables 1 & 2).

The early neonatal, neonatal, infant and under-five mortality rates were calculated to be 36.2 (95% CI: 31.5-41.5), 44.8 (95% CI: 39.6-50.7), 75.6 (95% CI: 68.8-82.9) and 104.2 (95% CI: 96.2-112.7) per 1000 person years respectively. There was significant difference in neonatal, infant and under five mortality rates between urban and rural residents, multiple and single births and those children born from multiparous mothers versus those with 2-4 births. On the other hand, infant and under-five mortality rates were significantly higher among boys and births to 35+ mothers compared to 25-29 year olds and also under five mortality rate was significantly higher among those mothers who had no education compared to those who had at least one year schooling and those with 30-34 year old compared to birth to 25-29 year olds (table 3).

In terms of water and sanitation, under five mortality rate was significantly lower among households who use protected water source, have any form of latrine facility and having soap in the house at the time of the interview (Fig. 1, 2, 3).

Among those factors included in the analysis, rural residence, no toilet facility, no soap in the house, 30-34 & 35+ year old mother at delivery, being first child for the mother (primipara), being multiple birth and baby boy were found to have statistically significantly (p<0.05) higher risk of dying during the first five years compared to urban residents, household with toilet facility, have soap in the house, 25-29 years old mothers at birth, mothers with 2-4 live births, single births and baby girls respectively (table 4).

Discussion

Globally, under-five mortality has decreased by 49%, from an estimated rate of 90 deaths per 1000 live births in 1990 to 46 deaths per 1000 live births in 2013. The average annual rate of reduction in under-five mortality has accelerated – from 1.2% a year over the period 1990–1995 to 4.0% for 2005–2013 – but remains insufficient to reach MDG 4. About 17,000 fewer children died every day in 2013 than in 1990, the baseline year for measuring progress. In 2013, the under-five mortality rate in low-income countries was 76 deaths per 1000 live births – almost 13 times the average rate in high-income countries (6 deaths per 1000 live births) (8). According to the United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), between 1990 and 2013, the under-five, infant and neonatal mortality rates decline 49%, 46% and 40% respectively (9). In our analysis, the infant and under five mortality rates are

calculated to be 75.6 and 104.2 per 1000 person years which is relatively higher that low-income countries report.

Studies in Sudan and Nepal showed that maternal education and family wealth levels were significantly associated with under-five mortality with lower education and lowest family wealth levels associated with higher risk of mortality (10, 11). Another cross national analysis of developing countries showed that economic growth is associated with widening poor–rich disparities in under-5 mortality (12). In our model, mother's education didn't maintain its significance when controlled for other factors this could be because vast majority of the mothers didn't have any formal schooling. Similarly, family socio-economic status indicator didn't show any significant effect on under-five mortality contradictory to the above studies which could be attributed to similarity in economic status of the families in the surveillance site.

An analysis of data from the demographic health survey in Bangladesh identified place of residence and mother's age significantly influence on under-five mortality but mother's education, socio-economic status of families, source of drinking water and toilet facility didn't show significant effect on under-five mortality (13). Mothers who have achieved primary or junior high school education were less likely to experience under-five death than mothers with no formal education at all. Similarly, mothers who were between the ages of 35 and 49 were about eleven times more likely to experience under-five deaths than those below the age of 20 years (14). Place of residence was the most consistent factor that affect under-five mortality in our analysis as rural children are at a higher risk of death in the first five year of life (HR=2.22, 95% CI (1.50-3.27)))compared to urban similar to the Bangladesh study. In addition, children born to 30-34 year old (HR=1.40 (95% CI: 1.06-1.83)) and 35+ year old (HR=1.53, 95% CI: (1.14-2.05)) compared to 25-29 year old mothers, showed a higher risk of death during the first five years of life similar to this same study. Contradictory to the Bangladesh report, our study showed significant negative effect on survival of children during the first five years of life with households not having toilet facility (HR=1.24, 95% CI: (1.03-1.50)). Another, unique finding is the effect of not having soap in the house (HR=1.22, 95% CI: (1.01-1.46)) that increased the risk of under-five mortality. Larine facility and availability of soap in the house are both related to sanitation and personal hygiene which has a direct effect on diarrheal diseases and other causes of death in children.

Conclusion and recommendation

The analysis for this article used data from a longitudinal surveillance with time of death is relatively accurately determined and the number of live births included is large that gives better analysis power. On the other hand, some important variables like health service utilization in general and place of delivery and ANC in particular are not included in the analysis which could affect its completeness.

Mortality rates in the first five years of life remained high in the surveillance community compared to the national report. Factors associated to child mortality in the first five years of life include being from rural area, household with no latrine facility, no soap in the house, age of mother at delivery being 30-34 and 35+ years, being multiple births and boy.

Therefore, any intervention programs targeted to reduce under-five mortality should prioritize rural children who mostly are disadvantaged in health service accessibility and educational programs to improve mothers' and family members' knowledge related to child rearing, feeding and health care seeking behaviors. The other relatively simpler intervention is access to toilet facility to families including children together with soap as a detergent for person hygiene that could reduce the burden of communicable diseases including diarrhea, one of the most common causes of under-five deaths in poor societies.

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Table 1: Number of deaths and live births by background characteristics, GG HDSS, 2006-2008

Characteristics	Number (%) of under five year deaths	Number of live births
Residence		
Urban	45 (4.9)	916
Rural	509 (11.2)	4,530
Sex of child		
Female	229 (8.9)	2,581
Male	325 (11.3)	2,865
Age of mother		
< 20	60 (8.6)	701
20-24	148 (9.2)	1,611
25-29	140 (8.6)	1,620
30-34	118 (13.2)	896
35+	88 (14.2)	618
Mother education		
No education	491 (10.7)	4,606
1-4 grade	23 (7.2)	321
5 or above	40 (7.7)	519
SES based on reported monthly income		
Poor	158 (11.8)	1,340
Average	119 (10.0)	1,191
Rich	205 (9.6)	2,134
Missing	72 (9.2)	781
Parity		
Primi	83 (11.0)	756
2-4	220 (8.5)	2,589
5+	251 (12.0)	2,101
Type of birth		
Single	499 (9.4)	5,335
Multiple	55 (49.6)	111
Total	**554 (10.2)**	**5,446**

Table 2: Water and Sanitation by number of deaths and live births, GG HDSS, 2006-08

Water and sanitation	Number & percent of death	Total number of live births
Source of drinking water		
Protected	81 (7.7)	1,048
Unprotected	401 (11.1)	3,617
Missing	72 (9.2)	781
Type of latrine		
Pit latrine or other type	285 (9.2)	3,100
None	197 (12.6)	1,565
Missing	72 (9.2)	781
Soap available at the time of interview		
Available	226 (8.9)	2,529
Not available	256 (12.0)	2,136
Missing	72 (9.2)	781
Total	554 (10.2)	5,446

Table 3: Mortality rates per 1000 by child, maternal, social and demographic factors

|	Mortality rates per 1000 person year			
	Early Neonatal	**Neonatal**	**Infant**	**Under-five**
Residence				
Urban	20.8 (13.3-32.3)	22.9 (15.0-35.0)	35.2 (25.0-49.3)	51.8 (38.9-68.9)
Rural	**39.3 (34.0-45.4)**	**49.2 (43.3-56.0)**	**83.7 (76.0-92.2)**	**114.5 (105.5-124.2)**
SES of family				
Poor	38.8 (29.7-50.7)	50.8 (40.3-64.0)	89.9 (75.7-106.5)	120.0 (103.6-138.8)
Average	33.6 (24.7-45.5)	42.0 (32.0-55.0)	69.9 (56.8-86.0)	102.0 (86.0-120.9)
Rich	38.0 (30.7-47.0)	45.0 (37.0-54.7)	70.0 (60.0-81.7)	97.7 (85.7-111.2)
Sex of the baby				
Girl	31.4 (25.3-38.9)	39.6 (32.7-47.8)	64.6 (55.7-74.8)	91.1 (80.5-103.1)
Boy	40.5 (33.9-48.4)	49.6 (42.2-58.2)	**85.5 (75.8-96.3)**	**115.9 (104.6-128.3)**
Age of mother				
< 20	30.0 (19.6-45.6)	40.0 (27.8-57.4)	67.3 (51.0-88.6)	87.7 (68.8-111.6)
20-24	36.0 (28.0-46.3)	42.2 (33.4-53.3)	71.1 (59.5-84.8)	94.4 (80.9-110.0)
25-29	28.4 (21.3-37.7)	35.2 (27.3-45.4)	63.2 (52.3-76.2)	88.4 (75.4-103.5)
30-34	45.8 (33.9-61.7)	**59.2 (45.6-76.8)**	93.1 (75.7-114.1)	**134.7 (113.7-159.1)**
35+	50.2 (35.5-70.6)	61.5 (45.1-83.5)	**103.7 (82.1-130.5)**	**144.1 (118.6-174.6)**
Mother's education				
No education	35.6 (30.6-41.4)	44.7 (39.1-51.1)	77.8 (70.4-85.9)	108.8 (100.0-118.2)
At least 1 year	39.3 (28.1-54.9)	45.3 (33.2-61.7)	63.5 (48.9-82.3)	**76.8 (60.5-97.3)**
Birth type				
Single	31.9 (27.5-36.9)	39.2 (34.3-44.8)	67.9 (61.5-75.0)	95.9 (88.2-104.3)
Multiple	**243.2 (173.8-334.3)**	**315.3 (237.7-410.6)**	**441.7 (355.2-539.0)**	**498.9 (409.7-595.6)**
Parity				
One (Primipara)	**49.0 (35.7-66.9)**	55.6 (41.4-74.5)	87.6 (69.5-110.1)	112.8 (92.0-138.1)
2-4 live births	25.9 (20.4-32.8)	34.0 (27.7-41.7)	60.6 (52.0-70.5)	87.7 (77.2-99.4)
5+ (Multiparous)	**44.3 (36.3-54.0)**	**54.3 (45.4-64.9)**	89.7 (78.3-102.8)	121.2 (107.9-136.1)
Total	**36.2 (31.5-41.5)**	**44.8 (39.6-50.7)**	**75.6 (68.9-82.9)**	**104.2 (96.2-112.7)**
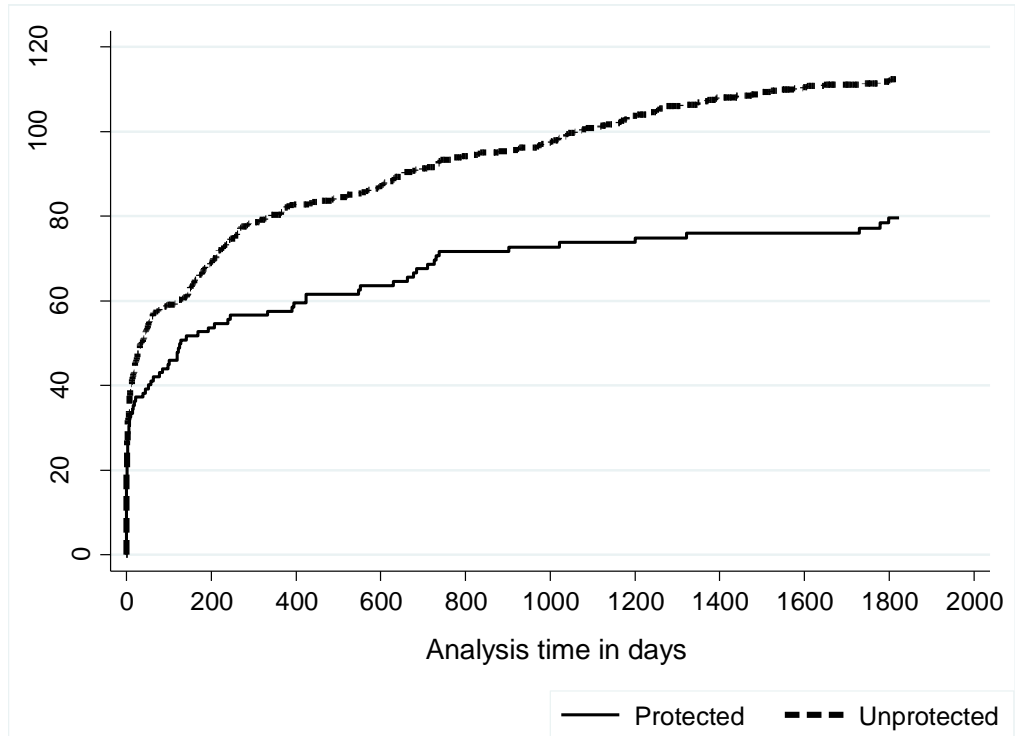
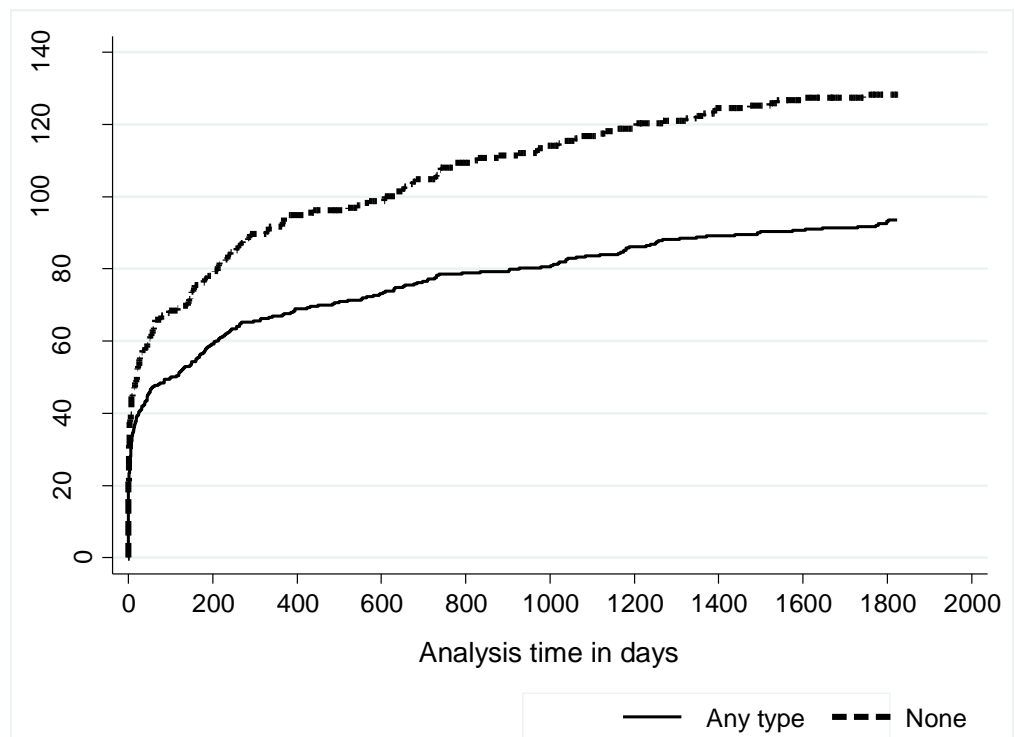Fig 1. Mortality rates by family source of drinking water, GG HDSS

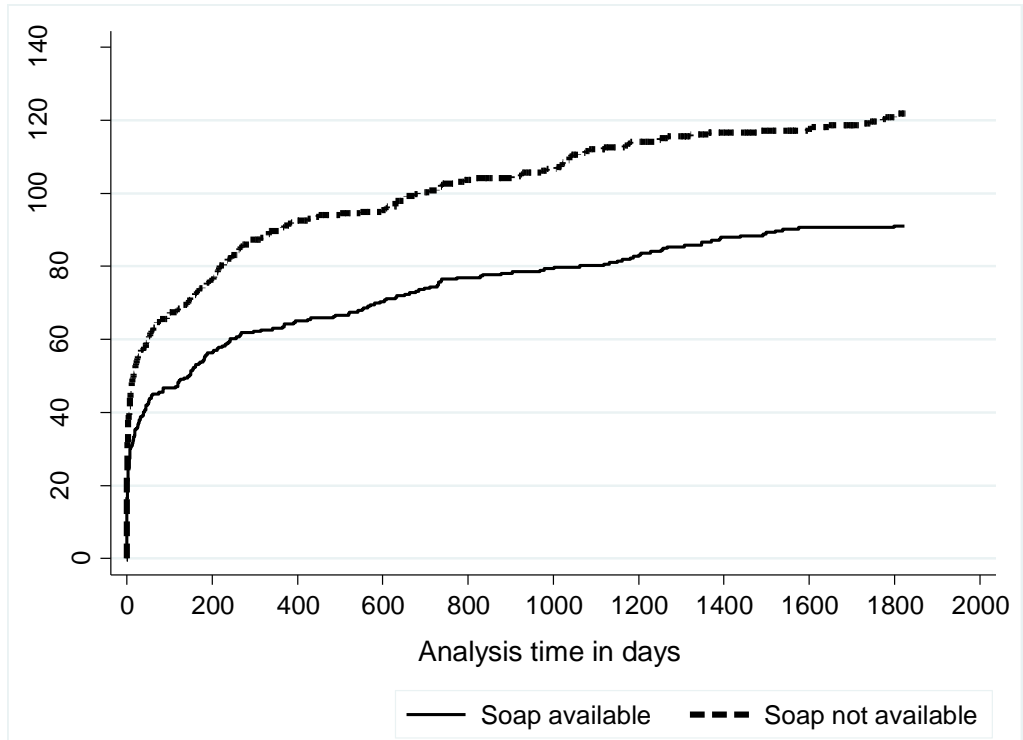Fig. 2: Mortality rates by family latrine facility, GG HDSS

Fig. 3: Mortality rates by availability of soap in the house, GG HDSS

Table 4: Factors associated with under-five mortality, Gilgel Gibe Field Research Center

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
At least 1 year (No education)	0.72**	0.98	1.10	1.10	1.09	1.12	1.22	1.14	1.18	1.20
	(0.55 - 0.94)	(0.74 - 1.29)	(0.81 - 1.48)	(0.81 - 1.49)	(0.81 - 1.48)	(0.83 - 1.51)	(0.89 - 1.67)	(0.83 - 1.57)	(0.85 - 1.62)	(0.87 - 1.65)
Urban resident (Rural)		2.27***	2.37***	2.29***	2.17***	2.12***	2.09***	2.02***	2.20***	2.22***
		(1.64 - 3.15)	(1.65 - 3.39)	(1.56 - 3.36)	(1.48 - 3.20)	(1.44 - 3.12)	(1.41 - 3.07)	(1.37 - 2.98)	(1.49 - 3.24)	(1.50 - 3.27)
SES Average (Poor)			0.88	0.88	0.88	0.90	0.89	0.89	0.95	0.95
			(0.70 - 1.12)	(0.70 - 1.12)	(0.70 - 1.12)	(0.71 - 1.14)	(0.70 - 1.13)	(0.70 - 1.13)	(0.75 - 1.21)	(0.74 - 1.20)
SES Rich (Poor)			0.87	0.87	0.90	0.93	0.90	0.90	0.99	1.00
			(0.71 - 1.07)	(0.71 - 1.07)	(0.73 - 1.11)	(0.75 - 1.15)	(0.73 - 1.11)	(0.73 - 1.11)	(0.80 - 1.23)	(0.80 - 1.24)
Unprotected water source				1.07	1.06	1.06	1.05	1.05	1.01	1.02
				(0.82 - 1.39)	(0.81 - 1.37)	(0.82 - 1.37)	(0.81 - 1.37)	(0.81 - 1.36)	(0.78 - 1.32)	(0.78 - 1.32)
No latrine (Latrine)					1.27**	1.24**	1.25**	1.25**	1.24**	1.24**
					(1.05 - 1.53)	(1.03 - 1.49)	(1.04 - 1.51)	(1.04 - 1.51)	(1.03 - 1.50)	(1.03 - 1.50)
No soap in the house (Soap)					1.24**	1.24**	1.24**	1.24**	1.21**	1.22**
					(1.03 - 1.49)	(1.03 - 1.49)	(1.03 - 1.49)	(1.03 - 1.49)	(1.00 - 1.45)	(1.01 - 1.46)
Age < 20 (25-29 yr)							1.02	0.87	0.94	0.92
							(0.73 - 1.43)	(0.58 - 1.30)	(0.63 - 1.40)	(0.62 - 1.37)
Age 20-24 (25-29 yr)							1.03	1.02	1.06	1.06
							(0.80 - 1.32)	(0.78 - 1.34)	(0.81 - 1.39)	(0.81 - 1.39)
Age 30-34 (25-29 yr)							1.48***	1.42**	1.41**	1.40**
							(1.14 - 1.93)	(1.08 - 1.85)	(1.08 - 1.85)	(1.06 - 1.83)
Age 35+ (25-29 yr)							1.63***	1.53***	1.52***	1.53***
							(1.23 - 2.15)	(1.14 - 2.05)	(1.13 - 2.03)	(1.14 - 2.05)
Parity - 5 or more (2-4)								1.19	1.13	1.13
								(0.95 - 1.51)	(0.89 - 1.43)	(0.89 - 1.43)
Parity – Primi (2-4)								1.53***	1.40**	1.42**
								(1.11 - 2.12)	(1.02 - 1.94)	(1.03 - 1.97)
Multiple Birth (Single)									6.67***	6.78***
									(4.94 - 9.01)	(5.02 - 9.15)
Baby boy (Girl)										1.31***
										(1.09 - 1.57)
Observations	5,446	5,446	4,665	4,665	4,665	4,665	4,665	4,665	4,665	4,665

Number in parentheses are 95% CI for the hazard ratio (HR)

*** $p<0.01$, ** $p<0.05$, * $p<0.1$