Original article

Determinants of infant mortality in Ethiopia: A study based on the 2005 EDHS data

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Abstract

Background: According to the Ethiopian Demographic and Health Survey of 2000, the infant mortality rate in Ethiopia was estimated at 96.8 deaths per 1000 live births. Continuous follow up studies about infant mortality are vital to the development of the country. The present study is an undertaking against the background of the prevailing high rate of infant mortality based on Ethiopian Demographic and Health Survey data gathered in 2005.

Objective: The main objective of this study was to determine socioeconomic, demographic and environmental factors/variables that could have impact on infant mortality in Ethiopia.

Methods: The study used data from the 2005 Ethiopian Demographic and Health Survey. The Kaplan-Meier method and Cox proportional hazards regression model were employed to analyze the data.

Results: The results of Kaplan-Meier estimation showed that most infant deaths occurred in the earlier months immediately after birth and then declined as the age of the infant advanced to 12 months. It was observed that about 47.9 % and 58.4% of the deaths, respectively, occurred in the first and second months of the follow up period. The Cox proportional hazards analysis identified "breast feeding status", "mother's age", "mother's level of education", "child birth order", "source of drinking water" and "sex of infant" as significant predictors of infant mortality.

Conclusion: In order to reduce infant mortality, awareness creation efforts have to increase birth spacing, improve the level of education of mothers, encourage breastfeeding, provide access to safe water and discourage teenage pregnancy. To this effect, existing health policy guidelines related to birth have to be improved, and perhaps new ones be formulated, in order to achieve the desired outcome of reducing infant mortality. [*Ethiop. J. Health Dev.* 2012;26(2):72-77]

Introduction

The rate of infant mortality is an important indicator of a nation's socioeconomic welfare. Infant mortality rate is very high in less developed countries. According to the data of Millennium Development Goals Indicators collected world-wide, infant mortality rate per 1,000 live births was estimated to have reached 47 in 2007; the estimated rate was 5 per 1,000 live births in developed regions and 51 per 1,000 live births in developing countries (1). One of the most important items in the Millennium Development Goals is to reduce infant and child mortality by two-thirds between 1990 and 2015 (2).

The literature on infant and child mortality shows that mortality is studied during two periods: neonatal and post-neonatal. Neonatal mortality is death occurring in the first month of life and is typically associated with events surrounding the neonatal period and the infant's delivery. The highest risk for infant death is in the neonatal period because of pre-term birth (28 %), severe infections (26 %), and asphyxia (23 %) (3).

Post-neonatal deaths are attributed mostly to environmental, socio-economic, demographic and other factors. Demographic researchers make a distinction between exogenous/socioeconomic (cultural, social, economic, community, and regional factors) and endogenous/biomedical factors (breastfeeding patterns, hygiene, sanitary measures, and nutrition). The effects of the socioeconomic variables are considered indirect because they operate through the biomedical factors. Bio-medical factors are called intermediate variables or proximate determinants because they constitute the middle step between the socioeconomic variables and child mortality (4, 5, 6).

The effect of income on infant and early childhood mortality at household level in Egypt was studied by incorporating socioeconomic and demographic variables (7).

Relationships of some socioeconomic factors such as mother's educational level, partner's education, and place of residence (urban/rural) as well as along economic status, ethnicity and sex of a child was studied in Tanzania (8). Another study in Tanzania investigated the effects of demographic, socio-economic, health seeking behavior and household environment on aggravating or impeding infant or child mortality (9).

The relationship between infant and child mortality and birth interval, age of a mother at the time of giving birth, birth order, with and without controlling for other relevant explanatory variables was studied in Malawi (10).

The effect of biological factors such as mother's age and birth order, and factors related to health service provision such as tetanus injection and use of antenatal services on infant mortality was examined based on data from Andre Pradesh, India (11).

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A study of three age-specific (neonatal, infant, and under-five) mortality by location (rural/rural), mother's educational attainment, religious affiliation, income status, and access to basic environmental services (water, sanitation and electricity) was done in Ethiopia (12).

According to the Ethiopian Demographic Survey (13) infant mortality rate for Ethiopia was estimated at 96.8 per 1000 live births. The estimates of infant mortality rate in 1990 and in 2007 for Ethiopia were 122 and 75 deaths per 1000 live births, respectively (14). An earlier estimate of the same showed that infant mortality rate in Ethiopia was higher for males (103.7 per 1000 live births) compared with females (86.6 per 1000 live births) for singletons. In the case of multiple births the rate was 477.8 per 1000 live births for males compared with 417.9 per 1000 live births for females. The gender difference was especially pronounced for infant mortality, where 1 in 11 boys died before his first birthday, compared with 1 in 14 girls (15).

In recent years, Ethiopia has made progress in improving health-care for children, reducing the under-five mortality rate by 42% as compared to that in 1990. Rapid population growth, however, has shown that the number of children dying now is almost constant. Infant and child mortality rates remained high, with most deaths being caused by easily preventable diseases, such as malaria, pneumonia and diarrhoea (14).

Given the above background information, this study had the objective to analyze the impact of demographic, socioeconomic and environmental variables on infant mortality based on data obtained from the Demographic and Health Survey of Ethiopia, 2005. The authors were fully aware that the Demographic and Health Survey of Ethiopia of 2011 will be released any time soon. Nonetheless, since the data of (16) have so far not been analyzed, it is believed that the findings based on these data shall be of paramount significance to stakeholders.

Methods

This study used cross-sectional secondary data (16) released by the Central Statistical Agency of Ethiopia. This is the second comprehensive and nationally representative population and health survey undertaken at national level in the country; the first survey was conducted in 2000. The objective of (16) was to provide estimates for the health and demographic variables of interest for the country, urban and rural areas (each as a separate domain), and 11 geographic areas (nine regions and two city administrations). The total number of children captured in the survey was 9,861. This figure included all live-births born to mothers who were interviewed about births during the time five years preceding the date of the 2005 survey. Since the information on some of the subjects was not complete this study utilized the data on 7,118 children for whom complete information was obtained.

The outcome variable of the study was the "survival time" of an infant, that is, the length of time from birth until the date of death measured in months (that is one to 12 months). The study investigated the relationship between infant mortality as measured in months (birth to completion of 12 months) and 11 predictors of mortality: birth spacing, mother's age at birth of a child, sex of infant, breastfeeding status, family size, marital status, mother's education, father's education, wealth index, area of residence, and source of drinking water.

The two functions that were used to summarize, describe and analyze survival data were the survival function and hazard function. The survival function measures the probability of a subject surviving or being event-free beyond a point in time. On the other hand, the hazard function describes the risk of an outcome like death or failure, in an interval after a specified time, conditional on the subject having survived to that specified time. In this study the survivor function was estimated by the Kaplan-Meier method (17). The log-rank test was employed to compare estimated survival curves of groups of subjects (18). The study used the Cox proportional hazards regression model (19) to identify determinant predictors of survival time thereby enabling the development of a regression model; this is the standard semi-parametric analytic method in survival analysis.

Results

Results of the Descriptive Analysis:

There were 9,861 live births born to women during the five years preceding the date of the survey/interview. From among these complete data were obtained for 7,118 cases. Of the 7,118 children, 3,466 (3,652) were females (males); 6,107 (1,011) were born in rural (urban) areas; 5,127 (1,991) were breastfed (not breastfed). The mothers of 6,715 children were married at the time of the interview. There were 926, 4,987 and 1,205 live births in the age groups 15-19, 21-34, and 35 years and above, respectively. There were 684 households of 1-3 members; 3,660 had household 4-6 and 2,774 households had more than 6 members. With regard to educational attainment, 5,457 mothers and 4,255 fathers had no education while 1,197 mothers and 2,041 fathers had primary education and the remaining 482 mothers and 822 fathers had secondary and above education. A total of 3,210, 2,730 and 1,178 households were classified as poor, medium income and rich, respectively. While 1,560 households had pipe water facility, 2,516 used water from protected sources and the remaining 3,042 used water from unprotected sources. A total of 718 (11%) infants died within 12 months after birth; this is by far a very high level of infant mortality. Most of the deaths occurred in the earlier months after birth and then the rate declined as the age of the infants got closer to 12 months (Table 1).

Table 1: **Socio-demographic and environmental characteristics, Ethiopian Demographic and Health Survey 2005, (*n* =7,118 births).**

Covariates	Category	Censored	Dead (%)	Total
Place of residence	Urban	943	68(6.7)	1011
	Rural	5457	650(10.6)	6107
Mother education	No Education	4855	602(11)	5457
	Primary	1179	101(8.6)	1280
	Secondary **+**	482	15(3.1)	497
Father education	No Education	3770	485(11.4)	4255
	Primary	1872	169(8.3)	2041
	Secondary **+**	758	64(10.1)	822
Breastfeeding	No	1546	445(22.4)	1991
	Yes	4854	273(5.3)	5127
Marital status	Currently Married	6044	671(10)	6715
	Currently not Married	356	47(11.7)	403
Birth order	1	1111	87(7.3)	1198
	2-4	2848	312(9.9)	3160
	5 and more	2441	319(10.1)	2760
Family size	1-3	636	48(7.0)	684
	4-6	3310	350(9.6)	3660
	7 and more	2454	320(11.5)	2774
Wealth index	Poor	2859	351(10.9)	3210
	Medium	2448	282(10.3)	2730
	Rich	1093	85(7.2)	1178
Source of drinking water	Pipe	1445	115(7.3)	1560
	protected	2256	260(10.3)	2516
	unprotected	2699	343(11.3)	3042
Mother's age	15-19	793	133(14.4)	926
	21-34	4569	418(8.4)	4987
	35 and above	1038	167(3.9)	1205
Child's sex	Female	3166	300(8.7)	3466
	Male	3234	418(11.4)	3652

The Kaplan-Meier survival curves show that, except for a slight (but not significant) difference in the two "breastfeeding status", there were no statistically significant differences between/among the various categories of the remaining categories. The log-rank test showed that the predictor "marital status" was not a significant predictor of infant mortality (*p*-value = 0.306); all the others were significant (Table 2).

Table 2: **Results of the log-rank test for the categorical variables, Ethiopian Demographic and Health Survey 2005, (*n* =7,118 births).**

Covariates	d.f.	chi-square	*p*-value
Place of residence	1	13.987	.000
Mother education	2	33.113	.000
Father education	2	19.503	.000
Breastfeeding	1	437.384	.000
Marital status	1	1.048	.306
Birth order	2	18.161	.000
Family size	2	15.365	.000
Wealth index	2	12.872	.002
Source of drinking water	2	16.867	.000
Mother's age	2	53.888	.000
Sex of child	1	15.795	.000

***Results of the Cox Proportional Hazards Regression Model*:**

The fitted Cox proportional hazards regression model showed that breastfeeding status, mother's age, mother's level of education, birth spacing, source of drinking water, and sex of an infant were significantly associated with the survival of infants. The following results are based on the regression analysis (Table 3).

Table 3: **Summary statistics the PHR model, Ethiopian Demographic and Health Survey 2005, (*n* =7,118 births)**

Covariates	Parameter Estimates	s.e.	Wald	d.f.	*p*-value	Estimated hazard ratio	Estimated 95% CI for hazard ratio	
							Lower	Upper
Breastfeeding status	1.473	.077	361.239	1	.000	4.362	3.747	5.077
Mother's age			34.541	2	.000			
15-19	.280	.119	5.538	1	.019	1.323	1.048	1.670
20-34	-.284	.093	9.357	1	.002	.753	.627	.903
Mother education			28.845	2	.000			
No education	1.343	.266	25.579	1	.000	3.832	2.277	6.449
Primary	1.099	.279	15.537	1	.000	3.000	1.737	5.181
Birth order			14.477	2	.001			
2-4	.292	.121	5.783	1	.016	1.339	1.056	1.699
5 and more	.450	.121	13.807	1	.000	1.568	1.237	1.989
Source of water			12.332	2	.002			
protected source	.314	.114	7.584	1	.006	1.368	1.095	1.711
unprotected source	.382	.109	12.233	1	.000	1.465	1.183	1.814
Sex of infant	-.221	.076	8.420	1	.004	.802	.691	.931

Breastfeeding: The reference group here was mothers who breastfed their children. Infants, who were not breastfed died at a rate which was about 4.362 times higher than infants who were breastfed (HR=4.362, CI: 3.747-5.077). The 95% confidence interval suggested that the risk of death for infants who were not breastfed could be 3.747 times as low and 5 times as large compared to those who were breastfed.

Mother's age: The reference group was the age group 35 years and above. Infants born to mothers of the age group of 15-19 died at a rate 32.3% higher than those born to the reference age group (HR=1.323, CI: 1.048- 1.670). For mothers' age of 20-34 the estimated HR=0.753 (CI: 0.627-0.903) showed that infants born to mothers of the age bracket 20-34 died at a rate which was about 25% lower than those born to mothers in the reference age group.

Mother's level of education: In this case, secondary and above level of education was taken as the reference category. The hazard rate of death for infants whose mothers had no education was 3.832 (CI: 2.227-6.449) and for primary education it was 3.000 (CI: 1.737-5.181) showing that infants born to mothers of these educational levels were 3.832 times and 3 times higher, respectively, than infants whose mothers had secondary and above education.

Birth spacing: The reference group, in this case, was taken as a single birth. Infants belonging to the 5 and more birth order category were about 57% more likely to die relative to the reference group (HR=1.568, CI: 1.237-1.989). On the other hand, infants of order two through four births died at a rate, of 34% higher than those of a single births (HR=1.339, CI: 1.056-1.699).

Sources of water: Households with access to pipe water form the reference category. It was found that the risk of dying of infants born in households with access to unprotected water was higher by 47% (HR=1.465, CI: 1.183-1.814) relative to those born in households with access to water from pipes. The estimated risk of death for infants born in households with access to protected sources of water (wells, springs) was 37% higher compared to those born in households with access to pipe water (HR=1.368, CI: 1.095-1.711). In either case the risk of death was higher than in the case of households having access to pipe water.

Sex of infant: The hazard ratio for female infants was found to be 0.802 (CI: 0.691-0.931) meaning that the risk of females dying was about 20% lower than that for male infants. The confidence interval indicated that the risk of death for female infants could be as low as 7% and as high as 31%.

Discussion

The Cox regression analysis provided above showed that the covariates: breastfeeding status, mother's level of education, mother's age, birth spacing, source of drinking water and the gender of an infant were significantly associated with their survival. The findings of previous studies discussed in the following part of this study corroborate our findings given under the results section above.

The findings in (4, 5) showed that the risk of mortality of infants was influenced by biomedical factors (breastfeeding patterns, hygiene, sanitary measures, and nutrition).

It was shown in (7) that household income did not affect survival through infancy but the effects were pronounced during early childhood; the impact of income was somewhat greater for educated mothers of higher socioeconomic status and where the household had access to pipe water

It was established that a higher level of mothers' education contributed to child survival by making women more likely to marry and enter motherhood later and have fewer children, utilize prenatal care and immunize their children (20).

No differences were observed in infant and child mortality on the basis of socioeconomic factors such as mother's educational level, partner's education, and place of residence (urban/rural) as well as along economic status, ethnicity and sex of a child. Demographic factors such as short birth intervals (shorter than two years), teenage pregnancy (below 20 years of age) and death of previous child were all significantly associated with increased infant and child mortality (8). While (8) concluded that education had no effect on infant mortality in Tanzania, the current study showed that education matters in that the higher the level of education attained by a mother the more positive impact it had on reducing mortality.

Infant mortality rate was higher for males than females (15, 21). Source of drinking water, birth spacing, early and late pregnancies, education level of mothers, occupation of the father, household income and survival status of older offspring had direct effects on infant mortality (22).

The effects of birth interval and maternal age were largely limited to the period of infancy on mortality (10). Education levels of mothers, socioeconomic status, mothers' age, birth spacing and breastfeeding had significant impact on infant and child mortality (9).
A strong association existed between infant and child mortality rate and poor household environmental conditions such as water, sanitation and electricity (12). Source of drinking water and sanitation facilities were found to be strong predictors of infant mortality (23). Child survival in Kenya was better for those who were of birth order 2-3, had access to safe drinking water and sanitation facilities (24).

Conclusions and Recommendations

It was observed that most of the deaths occurred in the first month after birth; the mortality rate declined in the later months of follow up (birth to 12 months). About 47.9 % and 58.4% of the deaths occurred in the first and second months of follow up period. As it came out clearly in the results section above, six socioeconomic, demographic and environmental predictors, namely breastfeeding status, mother's level of education, mother's age at birth, sex of infant, birth (spacing) and source of drinking water affected the survival of infants in Ethiopia.

More males than females died; the risk of female infant death was 20% lower than that for male infants. Infants who were not breastfed died at a rate which was about 4.362 times higher than infants who were breastfed. Infants born to mothers of the age groups of 15-19 and 20-34 died at a rate 32.3% higher and about 25% lower, respectively, than those born to mothers aged 35 and older. This showed that infants born to teenagers were likely to experience a very high rate of mortality. The contribution of higher level of education was quite apparent: infants whose mothers had secondary and above education experienced the lowest mortality rate. It was found that the mortality rate for birth spacing five and more and two through four births, respectively, were 57% and 34% higher than the reference group of a single births. The risk levels of dying among infants born in households with access to unprotected water and protected wells/springs, respectively, were 47% and 37% higher relative to households accessing pipe water.

On the basis of the foregoing, this study recommends that a lot of effort needs to be made in family planning programs to achieve increase in birth spacing intervals, improve the level of education of mothers, encourage breastfeeding, provide access to safe water and discourage teenage pregnancy. Towards achieving these objectives existing health policy guidelines related to birth have to be improved, and perhaps new ones need to be formulated to reduce infant mortality.

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