Determinants of Child Survival Chances in Rural Ethiopia

Ermias Dessie Buli*
Adama Science and Technology University, Adama, Ethiopia ermias.stat@gmail.com

Abstract

In a country like Ethiopia that has poor social conditions and more than 50% of its population illiterate and under the poverty line, the level of communicable diseases is found to be the highest magnitude (CIA World Fact book, 2009). So the importance of this study is to reveal the effect of socioeconomic, environmental, demographic and health related variables on child mortality in rural Ethiopia. The data set used originates from the demographic and health survey (DHS) conducted in Ethiopia 2005. The analysis was conducted using Cox proportional hazards model which analyses the effects of covariates on child mortality and other statistical methods. The study shows that source of drinking water, birth order number, sex of child, breast feeding status, wealth index of household, father's education, mother's education and family size have significant contribution on child mortality. Since educated parents have enough Knowledge on how to care their children, parents should be educated as well as mothers should be encouraged to breast feed their children. Furthermore, marriage at the right age is recommended and integrated child care and family planning programs are paramount. Government should improve society services like providing clean water which contributes to better children health status.

Key Words: *Child mortality, Cox proportional hazards model*

1. INTRODUCTION

Ethiopia is the third largest populous country in Africa with population of 73.9 million of which more than 84.2% live in rural areas (CSA, 2007). The land area of Ethiopia is estimated at about 1.1 million square kilometers and it is a federal democratic republic composed of 9 national regional states (NRS) Tigray, Afar, Amahara, Oromia, Somalia, Beni-Shangul-Gumuz, South Nations Nationalities and People Region (SNNRP), Gambella and Harari, and two administrative states (Addis Ababa city administrative and DireDawa council).

Ethiopia is one of the poorest countries in the world. Subsistence agriculture is the dominant sector in the economy. According to the World Fact book (2008) the proportion of population at the age group 15-64 year is 53.8 %. Total fertility rate is estimated to be 5.4 children born /woman and also fertility rate are estimated to be 2.4 and 6.0 children born/woman in urban and rural, respectively. In Ethiopia Under five mortality rate stands at 98 and 135 in the year 2005 per 1000 live births in urban and rural area, respectively (CSA,2005).

There are numerous causes of infant and under five mortality that have to be mentioned. Among these birth related causes, low household income, low parental education, unsafe water; poor sanitation facility and limited access to health care service are the dominant factors. Women and children are often more vulnerable to health threatening factors which are associated with poverty or inadequate standard of living. Although in Ethiopia living conditions differ largely between urban and rural dwellers, households living in the rural area are relatively much poorer than household living in urban areas. Rural areas of the country have poor access to health facilities, schools and piped water etc (UNICEF, 2008). The problem of child mortality is therefore most severe in rural areas.

This study focuses on the determinants of child mortality in the rural areas. More specifically examining how child mortality is related to household's environmental situations, demographic and socio-economic characteristics and health related variables is the center of attention. This may help in identifying households with high child mortality risks and targeting resources towards those households.
Normally poverty is the problem of least developed countries. Poverty is a pronounced deprivation of wellbeing. It is defined in terms of not having enough to eat, a low life expectancy, high rate of infant mortality, low educational opportunity, poor drinking water, inadequate health care and unfit housing conditions (Wolday, 2001). Thus the downtrodden rural society of the low income countries is fated to experience unhealthy environment which may result in loss of lives of both adults and children.

The primary objective of the study is to examine the household's environmental situation, demographic, socio-economic and health related variables that are associated with child mortality in rural Ethiopia.

Specifically the aims of the study are:

- To identify the factors that contribute to child mortality.
- To estimate the probability of child survival within five years life time.
- To develop a statistical model that determines child mortality.

In a country like Ethiopia that has poor social conditions (Education, housing, sanitation, etc) and more than 50% of its population illiterate and under the poverty line ,the level of communicable diseases is found to be the highest magnitude (CIA World Fact book ,2009). In studying child mortality, socio-economic, demographic and household environment have been given little attention by biomedical scientists since they primarily focus on the disease causing agents. So the importance of this study is to reveal the impact of the socio- economic, demographic and environmental variables on child mortality risks associated with household's environment in rural Ethiopia. Such information is critical for prioritizing public investments in order to maximize the health benefit for given resources, particularly in the context of achieving the targets set by the Millennium Development Goals (MDG) on child mortality.

The study will investigate the effects of environmental, demographic, socio-economic and health related variables on the child's survival chances in rural Ethiopia. The reason for selecting rural Ethiopia as study area is due to inadequate social services and the population is leading a life without adequate shelter or unacceptable housing condition, unsafe source of drinking water and no basic sanitation facilities.

This study has encountered an analytical problem that is related to the data set used in the study. That is, information on covariates refers to the time of the survey, but not necessarily to the exact time of exposure of the children. In other word, the analysis is restricted to the period 2000-2005 and it is assumed that no investments have been undertaken by the households in order to improve their living conditions. For example, the source of drinking water and sanitation facility are constructed based on the state of affairs at the time of the survey.

By and large, the empirical literature espoused the theoretical literature confirming that environmental, socio-economic, demographic, health related and maternal reproductive factors have significant impact on child mortality. Thus it can be said that child mortality is significantly influenced by source of drinking water, toilet facility, female education, household income, breast feeding, age of mother at birth, father's educational level and preceding birth interval.

2. DATA SOURCE AND METHODOLOGY

2.1 DATA SOURCE

The data set that used in this study originates from the Demographic and Health Survey (DHS) conducted in Ethiopia in 2005. DHS is a large cross-sectional data set that is comparable across countries. It contains information obtained from women aged 15-49 years regardless of whether they had any preschool children.

In the survey extended information is collected for children that are born five years before the survey was conducted. This means that information on children born prior to this period is not included since the longer the recall period the more likely the respondents misreport the case.

A total of 9861 children less than 59 months were identified in the households of selected clusters and among these 1358 and 8503 are living in urban and rural areas respectively. Then after a certain rearrangement the present study is based on 7395 children in rural areas that are the center of attention.

2.3 THE VARIABLES IN THE STUDY

The dependent variable used in this study is child survival time, which is measured as the duration in **month** starting from birth to death (if the event occurred) or from birth to the survey date (censored data).The independent variables in this study are classified into three groups such as bio-demographic, health related, socio-economic, environmental variables.

2.4 METHODOLOGY

The method that will be used in the study is basically survival analysis i.e. duration model like Cox-proportional hazard model and other statistical methods appropriate for the given data set.

Kaplan-Meier survival function estimator

Kaplan-Meier estimator of the survivorship function (Kaplan and Meier, 1958) is also called the product limit estimator. Kaplan-Meier estimator is used to estimate survival time of child and construct survival curve to compare survival experience of children between different categorical variables.

The Kaplan-Meier estimator of the survivorship function is defined as:

$$\hat{S}(t) = \prod_{t_{(i)} \le t} \frac{n_i - d_i}{n_i} = \prod_{t_{(i)} \le t} \left(1 - \frac{d_i}{n_i}\right) \quad (3.6)$$

where $t_{(1)},...,t_{(m)}$ is the set of m distinct death times observed in the sample.

d_i is the number of deaths at $t_{(i)}$

n_i is the number of individuals "at risk" right before the i^{th} death time.

Log rank test

The log rank test, sometimes called the Cox-Mantel test, is the most well known and widely used test. This test is based on weights equal to one, i.e. $w_i = 1$. Thus, the log rank test statistic becomes:

$$Q_{LR} = \frac{\left[\sum_{i=1}^{m} (d_{1i} - \hat{e}_{1i})\right]^2}{\sum_{i=1}^{m} \hat{v}_{1i}} \sim \chi^2(1) \quad (3.8)$$

Proportional hazards regression model

The proportional hazards model, also called Cox model, is a classical semi-parametric method. It relates the time of an event, usually death or failure, to a number of explanatory variables known as covariates. The proportional hazard function for an individual i is defined as follows:

$$h(t, x_i) = h_0(t).c(x_i) \qquad i = 1, 2....n \quad (3.9)$$

where $x_i = (x_{i1}, ...x_{ik})'$ is a column vector of k measured covariates for the i^{th} individual, $h_0(t)$ is the baseline hazard function and $c(x_i)$ is a link function.

$h_0(t)$ is the hazard for the respective individual when all independent variable values are equal to zero. That is, it is independent of the covariates.

Cox (1972) proposed a link function:

$$c(x_i) = \exp(x_i{}'\beta) \quad i = 1, 2.....n \quad (3.10)$$

where $\beta = (\beta_1.....\beta_k)'$ is a vector of regression parameters. The Cox proportional hazard model is thus defined as :

$$h(t, x_i) = h_0(t).\exp(x_i{}'\beta) \quad i = 1, 2......n \quad (3.11)$$

Here $exe(x_i{}'\beta)$ is the relative risk associated with the regressor. It is the exponential form of the estimated coefficients of the hazard model. It can be interpreted as the number of times that the baseline hazard is multiplied by each unit change in the covariates. $h_0(t)$ is an arbitrary and unspecified baseline hazard function.Consider two observations i and $i*$ that differ in their x-values with the corresponding linear predictors:

$$\Omega_{\text{i}} = \beta_1 x_{i1} + \beta_2 x_{i2} + ... + \beta_k x_{ik}$$

and

$$\Omega_{\text{i*}} = \beta_1 x_{i*1} + \beta_2 x_{i*2} + ... + \beta_k x_{i*k}$$

The hazard ratio for these two observations,

$$\frac{h_{i(t)}}{h_{i^*(t)}} = \frac{h_{o(t)*e^{\Omega\text{i}}}}{h_{o(t)*e^{\Omega i*}}} = \frac{e^{\Omega i}}{e^{\Omega i*}}$$

is independent of time t. This implies that the hazard ratio does not depend on time. This is to say that the risk of failure is the same no matter how long the subject has been followed (this is main assumption of the Cox-proportional hazard model).

Interpretation of the regression coefficient β's. Consider a one unit increase in one covariate x_p and fix the remaining covariates; i.e

$$x_i = (x_{i1}, ..., x_{ip}, ...x_{ik}) \text{ and } x_{0i} = (x_{i1}, ..., x_{ip} + 1, ...x_{ik})$$

Then the log hazard ratio is:

$$\ln\left[\frac{h(t, x_{i0})}{h(t, x_i)}\right] = \ln\left[\frac{h_0(t).e^{\beta_1 x_{i1} + ...\beta_p(x_{ip}+1) + ...\beta_k x_{ik}}}{h_0(t).e^{\beta_1 x_{i1} + ...\beta_p x_{ip} + ...\beta_k x_{ik}}}\right] = \beta_p$$

Thus, the hazard ratio is :

$$\frac{h(t, x_{i0})}{h(t, x_i)} = e^{\beta_p}$$

Thus, β_p is the change in log hazard ratio at anytime with a unit change in the pth covariate x_p, adjusting for the effect of other covariates.

The rate of change in hazard ratio is:

$$\frac{h(t, x_{i0}) - h(t, x_i)}{h(t, x_i)} = e^{\beta_p} - 1$$

- $(e^{B_p} - 1)*100\%$ is the percentage change in the hazard for a unit change in x_p adjusting for the remaining covariates.

3. ANALYSIS AND DISCUSSION

The fundamental building block of survival analysis is an estimate of the survival function. Thus, after providing a descriptive analysis of the overall survival experience of the child, we usually turn our attention to a comparison of the survivorship experience across the different levels of a categorical variable. We use log-rank test. That is, the log rank statistic helps to test the null hypothesis that there is no difference in the survival experience of children between categorical variables at any time point. The results of the log rank test are displayed in Table 3.1.

As indicated in Table 3.1, the different levels of the categorical variables such as mother literacy, source of drinking water, breast feeding status, family size, father literacy, sex of child, birth order number, wealth index and age of mother's at birth are statistically significant. This means that children mortality is not the same in each category of these covariates. However, sanitation facilities, mother work status, usage of bed net for sleeping, place of delivery and current marital status are not statistically significant. One possible explanation for this is that, these are homogeneous covariates in rural part of Ethiopia.

Table 3.1 Log-rank test Comparison of Survival function between different levels of categorical variables.

Covariates	**Chi-Square**	**DF**	**P-Value**
mother literacy	5.7524	1	0.0165**
Source of drinking water	166.8788	1	0.0000*
family size	171.1577	2	0.0000*
sanitation facility	0.6743	1	0.4116
Have bed net for sleeping	0.08290	1	0.7734
Current marital status	0.09429	1	0.7588
father literacy	9.3543	1	0.0022*
mother work status	0.3517	1	0.5532
Sex of child	5.7392	1	0.0167**
Place of delivery	1.6598	1	0.1976
Wealth index	5.4983	2	0.0164**
Birth order number	13.09182	2	0.0014*
age of mother at birth	16.3452	2	0.0003*
Breast feeding status	301.0367	1	0.0000*
*significant at 1%	**significant at 5%		

Estimation of model parameters

The estimated model is the Cox proportional hazards model:

$$\lambda(t, x_i) = \lambda_0(t).\exp(x'_i \beta) \quad i = 1.....k$$

The variables considered in the model are birth order number, mother's age at birth, mother's education, father's education, source of drinking water, breast feeding, wealth index, sex of child and family size. The result of the fitted proportional hazards model is given in Table 3.2.

Table 3.2 Partial likelihood estimates for fitted proportional hazards models

	B	SE	Wald	df	Sig.	Exp(B)
Mliteracy	-.266	.128	4.295	1	.038**	.767
water	-1.038	.088	138.440	1	.000*	.354
Fliteracy	-.172	.096	3.222	1	.073***	.842
sex	-.180	.078	5.249	1	.022**	.835
beastfeeding	-1.151	.082	199.326	1	.000*	.316
wealth			15.746	2	.000*	
wealth(2)	.352	.099	12.685	1	.000*	1.422
wealth(3)	.291	.101	8.325	1	.004*	1.338
groupage			5.983	2	.050***	
groupage(2)	-.270	.124	4.750	1	.029**	.764
groupage(3)	-.395	.169	5.468	1	.019**	.674
groupbord			23.929	2	.000*	
groupbord(2)	.138	.138	1.004	1	.316	1.148
groupbord(3)	.639	.165	15.070	1	.000*	1.894
Groupfamily			87.084	2	.000*	
groupfamily(2)	-.824	.118	48.732	1	.000*	.439
groupfamily(3)	-1.317	.141	86.683	1	.000*	.268

*significant at 1% **significant at 5% ***significant at 10%

Interpretation of results and discussion of child mortality

As indicate in above section, the interpretation of the estimated coefficient of Cox proportional hazards regression is similar to logistic regression. Hence the relative risk association with the covariates (x_i) is exp(βx_i). In our model all the covariates are categorical variables and the hazard ratio of i^{th} group of the covariate compared to the reference group is exp(β_i), keeping all other covariates fixed. If exp(β_i) < 1, the hazard rate for death of child that belongs to the i^{th} group is smaller than the reference group. On the other hand, if exp(β_i) >1,the hazard rate (death of child) that belongs to the i^{th} group is greater than the reference group.

As indicated in Table 3.2 , the covariates included in the model : source of drinking water, birth order number, sex of child, breast feeding status, wealth index of household , mother's education and family size have statistically significant contribution for child mortality (5% level of significant). Father's education and age of mother at birth are also significant at the 10% level.

Consistent with expectations and other studies (Ali, 2002; Jocoby and Wang, 2004), the Cox regression results predicting child mortality as indicated in Table 3.2, show that maternal education has a significant contribution for child mortality in rural Ethiopia. This result indicates that children whose mothers are literate have more survival chance than those with illiterate mother. This may be due to the fact that educated mothers are more likely to use the health services, feed their children better and act in various ways to improve traditional means of health care. Children born from educated mothers have a 23.3% less mortality risk as compared to those from uneducated mothers. The results also indicate that the mortality risk of children from educated fathers is 15.8% less than those from uneducated fathers.

Children whose mother's age at birth lies in groupage2 (21-34 years) and groupage3 (35 and above years) have more survival chance than mother's whose age at birth is less than 20 years (reference group), i.e, children from mothers whose age at birth lies in groupage1 and groupage2 have 23.6% and 32.6% less mortality risk as compared to mothers whose age at birth is less than 20 years, respectively. Therefore, child mortality has indirect relationship with the age of mother at birth.

Children who are breast fed have more survival experience than those who are not breast fed. That is, the likelihood of child mortality of children who are breast fed is 69% less as compared to those who are not breast fed. Child mortality is also influenced by demographic variables like sex. Male children are more likely to die than female children. That is, female children have a 16.5% less mortality risk than male children. Similar results are reported by Ali (2002) and Krzysztol (2007).

As indicated in table 3.2, children who belong to groupedfamily2 (2-4 members) and groupedfamily3 (>6 members) have more survival chance than that of groupfamily1 (1-3 members). One of the strange results we get was that children from families with 4-6 and more than 6 members have 56% and 73% less mortality risk, respectively, than children with 1-3 family members. Many recent studies have focused on the improvement in survival of children due to the presence of large family size. Children from large family size often get more care, since older children can assist in the care of younger children.

Previous studies show that the risk of mortality is positively related to birth order of the child (Ali, 2004; Krzysztol, 2007). As indicated in Table 4.3, children whose birth order number is greater than 4 have less survival chance than those who are first born (reference category). When expressed in percentage, children whose birth order is greater than four have 89.4% more mortality risk as compared to those who are the first children. But there is no statistically significant difference between the first birth order number (reference group) and birth order number (2-4).

From the result in table 3.2, a child whose parents use covered water has more survival chance than those who use surface water. That is, a child whose parents use covered water has a 64.6% less mortality risk as compared to a child whose parents use surface water. Therefore, the improvement of water supply is expected to be inversely related to mortality risk. As mentioned earlier in the literature review, water supply and higher quality sanitation facilities are epidemiologically directly related to lower mortality.

According to the results in Table 3.2, wealth index has a contradictory result to our expectation. That is, as the wealth index increases, the risk of child mortality will also increase. For instance, children whose families are in medium wealth range are 1.422 times more likely to die as compared to children from poor family. In rural part of Ethiopia agriculture is the dominant sector in the economy. Households who are relatively rich do have high labor burden (to increase their production), and hence, devoted much time of their time in productive activities and less time in child health care.

In general, the findings revealed that socio economic, environmental, demographic and health related variables are important determinants of child mortality.

4. Conclusion and Recommendation

Child survival is an important aspect of public health and its epidemiological appraisal may provide important clues towards public health programs. Child survival may get affected through biological and behavioral channels which are socioeconomic, environmental, demographic and health related variables. The results of this study indicated factors that are associated with child mortality in rural Ethiopia through Cox proportional hazards model by analyzing the effect of the covariates and censored observations. The findings of the study demonstrate that different factors such as mother's education, father's education, birth order number of children, age of mother at birth, sex of child, family size, source of drinking water and breast feeding status have statistically significant impacts on the survival chance of a child.

The study shows that mother's education and father's education have a significant effect on the survival of child, that is, children born to literate mothers and father are less likely to face the risk of death. Also age of mother at birth and family size have a positive impact on the child survival, that is, as age of the mother at birth and family size increase, the survival chance of a child will also increase.

Sex of the child was found to be one of the determinants of child mortality. According to our results, female children have a relatively less risk of death than male children. Breastfeeding status and birth order number were also found to be have a contribution to child mortality, that is, children at a higher birth order number have higher risk of child mortality and children who are breast fed have less risk of death before the age of five.

The study also shows, that source of drinking water has a significant effect on child mortality. A child that comes from a household with access to covered/protected well water has lower risk of death than a child that belongs to a household which consume water from unprotected sources.
Contrary to our expectation, the results showed inconsistent relationship between socioeconomic status (measured by wealth index) and child mortality, that is, children from poorest households have less child mortality than richest and middle household classes. This is difficult to explain and requires more detailed examination about the data collection and the wealth index as a valid tool for measuring socioeconomic status.
Child mortality reduction is an integral part of social protection, an efficient means of reducing poverty and increasing future growth. Poverty has a disabling impact on the minds, bodies and future potential of children and leads to poor human development and weak economic performance. Investing in children's health, development, and social well-being is a cost-efficient and social endeavor providing lifetime gains to the child and overall benefits to the society.

One of the Millennium Development Goals is the reduction of child mortality by two-thirds in 2015. In order to achieve this goal, identifying the important socioeconomic, environmental, demographic and health related factors that affect child mortality, and acting on them is mandatory. Based on our findings, we make the following recommendations:

- Since educated parents have enough Knowledge on how to care their children, parents should be educated to reduce child mortality.
- Since breast feeding has a great role for reduction of child mortality, mothers should be encouraged to breast feed their children.
- According to our finding, early marriage has a positive impact on child mortality rate. In order to reduce child mortality, marriage at the right age is recommended.
- Integrate child care and family planning programs. This can help by delaying the birth interval to ensure the survival of a child.
- Government should improve society services like providing clean water which contributes to better children health status.

REFERENCES

- Aguirre, G.P. (1996), "Child Mortality and Reproductive Patterns in Urban Bolivia." Center for Demography and Ecology (CDE) Working Paper No. 95-28.

- ALI, Hala Abou. (2002), "The Effects of Water and Sanitation on Child's Mortality in Egypt", Environmental Economics Unit, Department of Economics, Goteborg University.
- Ali, SM. (2001), "Poverty and Child Mortality in Pakistan" Micro Impact of Macroeconomic Adjustment Policies (MIMAP), Technical Paper Series No. 6.
- Becker, G. S. (1981), "Altruism in the Family and Selfishness in the Market Place," Economica 48,1-15.
- Becker, G. S, Glaeser, E.L. And Murphy K.M.(1999), "Population and Economic Growth" American Economic Review, Papers and Proceedings; 89(2):145-149.
- Breslow.N (1974),"Covariance Analysis of Censored survival data", Biometrics 30, 89-99.
- CIA World Fact Book .(2009), Ethiopia people 2009 from the internet (http://www.theodora.com/wfbcurrent/ethiopia/ethiopia_people.html).
- Cingo, A. (1998), "Fertility Decisions When Infant Survival is Endogenous" Journal of Population Economics; 11:21-28.
- Claeson, Griffin, Johnston, Mclachlan, Soucat, Wagstaff and Yazbeck (2005), Health, Nutrition and Population Chapter 18: P.203.
- Cleves, M.A., W. W.Gould, and R.G. Gutierrez (2004), "An Introduction to Survival Analysis Using Stata" Revised Edition; Stata Corporation, Texas.

- Clive J.Mutanga,(2007) ,"Evironmental Determinats of Child Moratlity in Kenya" United Nations University.
- Cox, D.R (1972), "Regression Models and Life Tables" Journal of the Royal Statistical Society; B (34): 187-220.
- Cox and Oakes (1984), "biometrical centenary:survival analysis" Biometrika 23 99-142.

- CSA (2005), DHS Ethiopia 2005, Ethiopia Demographic and Health Survey 2005. Addis Ababa, Ethiopia and Calverton, Maryland USA: Central Statistical Authority and ORC Macro.
- CSA (2007),Population and housing census result: Central Statistics Agency of Ethiopia.
- DHS/WB (2005), DHS Dimensions: A Semi-Annual Newsletter of the Demographic and Health Related Surveys Project; 4(2).
- Efron (1977)),"Covariance Analysis of Censored survival data", Biometrics 35, 42-43.
- Fayissa, B. (2001), "The Determinants of Infant and Child Mortality in Developing Countries: The Case of Sub-Saharan Africa" The Review of Black Political Economy.
- Grambsch, P. M. and T. M. Therneau (1994), "Proportional Hazards Tests and Diagnostics based on Weighted Residuals" Biometrika 81: 515-526.
- Hailemariam.A and Tesfaye.M(1997) "Determinants of Infant and Early Childhood Mortality in Small Urban Community of Ethiopia using Hazard Model Analysis" Ethiopia Journal of Health Department :11(3):189-200.
- Heckman, J. J. (2000), "Policies to Foster Human Capital," Research in Economics 54, 3-56.
- Hondroyiannis, G. and E. Papaetrou (2002), "Demographic Transition in Europe" Economics Bulletin; 10(3): 1-8.
- Hosmer and lemeshow(1998),"Regression Modeling of time to event data" .
- Jacoby H., Limin Wang (2004), "Environmental Determinants of Child Mortality in Rural China: A competing Risks Approach". World Bank Policy Research Working Paper 3241.
- Kalemli-Ozcan, Sbnem (2002), "Does the Mortality Decline Promote Growth?". Journal of Economic Growth, July (2002).

- Kaplan, E. L. and P. Meier (1958), "Non-Parametric Estimation from Incomplete Observations." Journal of the American Statistical Association 53:457-481.
- Kim TH (2004), "determinants of Child and Infant Mortality in Korea 1955-1973".
- Krzystof.T (2007), "The Correlates of Infant and Childhood Mortality" A theoretical overview and new evidence from the analysis of longitudinal data from Bejsce parish register reconstitution study 18th-20th centuries, Poland.
- Lancaster, T. (1990), "The Econometric Analysis of Transition Data" Econometric Society Monographs; Cambridge University Press: New York.
- Lee L.F., M.R. Rosenzweig and M.M. Pitt (1997), "The Effects of Improved Nutrition, Sanitation, and Water Quality on Child Health in High Mortality Populations". Journal of Applied Business Research; 13(1).
- Lyun B.Folasade(2000), " Environmental Factors,Situation of Women and Child Mortality in South West Nigeria".
- Madise, N.J., and I. Diamond (1995), "Determinants of infant mortality in Malawi: An analysis to control for death clustering within families". *Journal of Biosocial Sciences* 27: 95-106.
- PARK, K. (2005), "Preventive Medicine in Obstetrics, Pediatrics and Geriatrics", *PARK'S textbook of preventive and social medicine*, (18th edition) India: BHANOT (2005); Pp 414-422.
- Schellenberg, J.A., R. Nethan, S.Abdulla, O. Mukasa, T.J. Marchant, M. Tanner and C. Langeler (2002), "Risk Factors for Child Mortality in Rural Tanzania" Tropical Medicine and International Health; 7(6): 506-511.
- Schoenfeld, D.(1982), "Partial Residuals for the Proportional Hazards Regression Model" Biometrika; 69:239-241.
- UNICEF. (2006): *State of World's Children 2006*.
- UNICEF (2008), Population Statistics at A Glance: Ethiopia Statistics Browsed from the internet(http://www.unicef.org/specialsession/about/sgreportpdf/01_InfantAnd Under- FiveMortality_D734Insert_English.pdf).
- United nation (2007), "United Nations human development index".
- Wang, L. (2002), "Health Outcomes in Low income Countries and Policy Implications: Empirical Findings from Demographic and Health Surveys."
- White.L (2006), "determinates of child and infant mortality in Andre Pradesh", India
- WHO (2001), Macroeconomics and Health: Investing in Health for Economic Development. Report of the Commission on Macroeconomics and Health.
- Wolday Amha (2001), Addressing Poverty in Ethiopia: Concepts, Measurements, and Challenges. Training Manual, Addis Ababa.
- Woldemichael G. (1998), "The effects of water supply and sanitation on childhood Mortality in urban Eritrea", Stockholm Research Reports in Demography No. 127, Demography unit, Stockholm University.
- World fact Book (2008) , "Ethiopian population" Ethiopia.
- Zakir, M. and P. V., Wunnava (1997), "Factors Affecting Infant Mortality Rates: Evidence from Cross-Sectional Data", Applied Economics Letters; 6:271-273.