



**LUND UNIVERSITY**  
School of Economics and Management

**Master in Economic Development and Growth**

## **Macroeconomic Conditions and Infant Mortality in Ethiopia: A Survival Analysis**

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*Abstract:* This study seeks to analyze the impact of macroeconomic condition on infant survival in Ethiopia using Demographic & Health Survey data with macro variables (GDP & inflation). It also seeks to explore the underlying other micro determinants of infant mortality applying survival analysis. The result indicates that macroeconomic condition has insignificant impact on child health in Ethiopia. Rather the micro level variables are found to be the most important determinants. Behavioral factors, maternal, environmental and socioeconomic factors play crucial role. Paternal education, access to safe drinking water, information access, and other utilities like electricity have positive impact on child survival. It has also been found that there is regional variation in mortality rate. The risk of dying is high in rural areas compared to urban areas indicating that modern health facilities are urban-biased.

*Key words:* Infant Mortality, Macroeconomic Conditions, Survival Analysis

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## 1. INTRODUCTION

Developing countries especially Sub-Saharan African countries have been associated with stagnating or even in some instants declining per capita income particularly in 1970's and 1980's with deteriorating living standards; and most development indicators are observed to be the worst in this part of the world. In Sub-Saharan Africa, life expectancy at birth was only 45 years in between 1970 and 1975 which increased to 52 years in the second half of the last decade; infant and child mortality rate are still among the highest in the world. Infant mortality rate was as high as above 130 deaths per 1000 live births in between 1970 and 1975 whereas under five mortality rates was about 190 per 1000 live births in 1980's. But for the last thirty years, there has been improvement in the region as a whole in relation to these development indicators. The average infant mortality in between 2005 and 2010 has reached to 85 per 1000 live births whereas under-five mortality declined to 136 per 1000 children (United Nations, 2011).

The interesting fact is that most of these countries have experienced rising life expectancy, falling infant and child mortality since the second half of the twentieth century regardless of economic growth. Until the 1990 when most Sub-Saharan African countries were hit hard by AIDS, there had been improved health in general at constant and even declining level of income (Preston, 1975; Soares, 2007) implying that improved health is not always driven by economic growth. If we look at economic growth in Sub-Saharan Africa, it had ups and downs especially in the 1980s. GDP per capita for the region in 1950 was around USD \$430 PPP (const.) which reached around USD 580 in the 1980. After 1980, GDP per capita for the region started to decline; in 1993 it declined to 489 USD (World Bank, 2011). In spite of this fact, there are scholars such as Easterlin (1999) who argue that the observed improvement in health since the Second World War in most developing countries is mainly due the general improvement in living standards and the resulting reduction in infectious diseases which were main killer at early life. Therefore it remains to be puzzling how economic growth contributes to the improved development indicators in most developing countries which require further study.

Like the rest of Sub-Saharan African countries, Ethiopia has high infant and under five mortality though declining in recent times.

## 1.1. Research Question

In orthodox economic theories, the well being of societies is often measured by the money income they earn and what matters for development policy makers is peoples command over commodities (Anand and Ravallion, 1993). But Amartya Sen, *Nobel Laureate*, argue that this orthodox measure of the well being of the society is inadequate to capture the causal influence on the quality of life and on the chances of survival. For Sen, the value of living is not the mere possession of commodities; it is rather the capabilities to avoid morbidity, mortality or hunger. Then after infant and child mortality has been one of the most important development indicators and measure of the well being of the society. That is the reason why reducing under-five mortality by two-thirds in between 1990 and 2015 is included among the eight Millennium Development Goals (MDGs). And as policy direction most governments and non-governmental organizations in developing countries are working to reduce the number of children who die prematurely of preventable infectious and parasitic diseases.

Now the question is ‘how much has economic growth contributed to the observed infant mortality in developing countries as a whole?’. Undeniably there is *prima facie* association between mortality in general and economic well being. But the empirical findings and country experience reveals the mixed picture about the role of economic growth and economic fluctuations on child health. In most developed countries, the empiric is that in times of recession mortality (even those of infant) decreases. Ruhm (2000) using US data finds that infant mortality decreases when unemployment goes up; Gerdtham and Ruhm (2002) confirm this finding using OECD data. The procyclicality of mortality according to Ruhm (2000) is because of the fact that in times of economic upturns, leisure time declines and it becomes costly for especially mothers to undertake health-producing activities for themselves and their children consequently mortality goes up.

On the other hand, Gerdtham and Johannesson (2004) came up with a finding that mortality increases in bad economic times using Swedish data. Bhalotra (2007) using Indian data finds limited impact of favourable aggregate income shock on mortality but temporary down turn in the economy raises mortality. Therefore the relationship in a developing country like Ethiopian context is open to empirical investigation.

The present government of Ethiopia has given much attention to the health sector; for example in 2000, general government health expenditure as percent of total spending was around 8.5 percent and in 2009 it increased to 11.5 percent. This is relatively good performance when compared to other Sub-Saharan African countries. For example, Ghana’s health expenditure as

percent of total government expenditure was around 9.2 percent in 2009, Kenya had 5.4 percent, and South Africa had 9.3 percent. On average public health expenditure as percent of total health expenditure in 2009 for Sub-Saharan Africa was around 44 percent whereas Ethiopia had 47 percent above the Sub-Sahara average. And health expenditure per capita has increased to \$14 in 2009 which was only \$5.3 in 2001 which is still yet far below the Sub-Saharan average of \$76 in 2009 (World Bank, 2011). The coverage in terms of immunization against DPT (Diphtheria, Pertussis and Tetanus) and against measles has improved much. In 2009 around 80 percent of the children were vaccinated against DPT and 75 percent against measles which was 56 percent and 52 percent respectively in 2000. It was only 28 percent of the total population with improved water access in 2000 which increased to 38 percent in 2008 (World Bank, 2011). Notwithstanding the government's recent effort in health sector, Ethiopia has still the highest infant and child mortality. And there is little empirical evidence why the country has persistently high infant mortality and worst child health in general and how macroeconomic environment affects it. Hence this study seeks to explore the underlying determinants of child health in Ethiopia and how macroeconomic conditions influence the level of infant mortality.

## **1.2. Infant Mortality Trend in Ethiopia**

As we can see from Figure (1) below, infant mortality in Ethiopia has shown downward trend as long as we can tell since the second half of the twentieth century<sup>1</sup>. Starting from 1950s up until early 1970s, there was a continuous improvement in infant mortality; it was as high as 199 deaths per 1000 live births in 1950s and declined to 135 per 1000 live births in between 1975 and 1980, it was a 32 percent reduction in infant mortality in a span of thirty years. In same time interval the Sub-Saharan African average declined from 177 deaths per 1000 to 122 per 1000. On the other hand, Western European countries had on average about 45 per 1000 even in 1950's and declined to 13 deaths per 1000 live births in between 1975 and 1980. So Ethiopia had above Sub Saharan average in this time period and far below the developed countries of Western European countries. But roughly in between 1980 and 1985, the downward trend observed between 1950s and 1980 had stalled and had shown four percent increment in this short period of time. In this period infant mortality increased from 135 to 140 per 1000 live births. This was a time of drought and famine in most parts of Ethiopia especially the Northern part. Then after late 1980s the downward trend has continued and it reached 72 infant deaths per 1000 live births in between 2005 and 2010 (United Nations, 2011). This downward trend is believed to continue for the years to come as the forecast shows. If the present trend for infant mortality continues,

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<sup>1</sup> It is only since 1950s that there is reliable official data on all demographic variables for most Sub-Saharan African countries including Ethiopia.

then it may contribute to the reduction in under-five mortality which helps the country to achieve one of the Millennium Development Goals (MDGs) i.e. reducing under-five mortality by two-third in between 1990 and 2015.

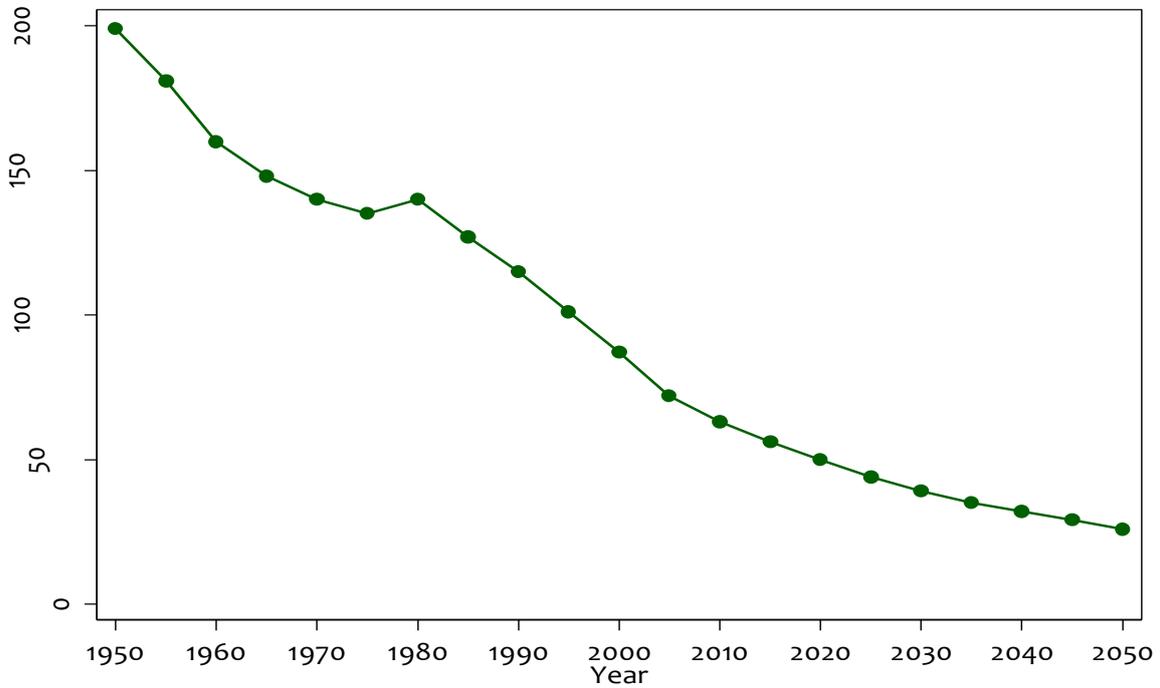


Figure (1): Historical and Forecast Trends of Infant Mortality rate in Ethiopia between 1950 and 2050

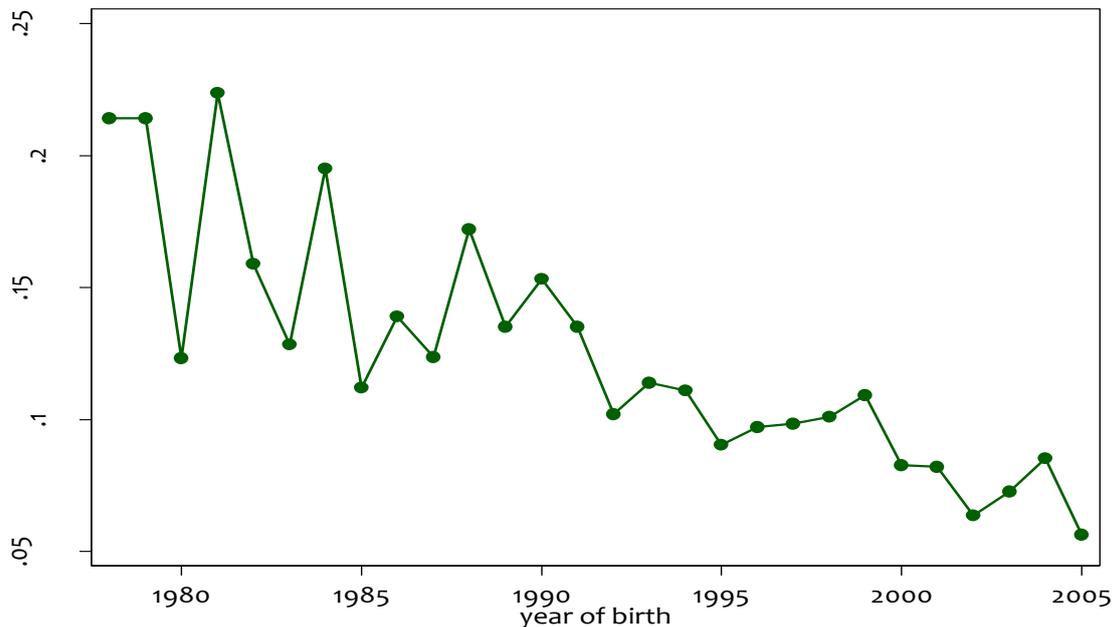


Figure (2): Ratio of infants who died as percent of birth (Ethiopian Demographic and Health Survey 2005)

Figure (2) above shows the mortality rate among infants computed based on the Ethiopian Demographic and Health Survey of 2005 for the whole sample. It has followed the same trend as the general one.

### 1.3. Macroeconomic Condition in Ethiopia

Ethiopian GDP per capita measured at PPP was as low as USD \$300 in early 1980s; there had been improvement in GDP since 1980 until the famine year of 1984 and 1985. In those famine years, there was significant fall in GDP per capita; then after 1986 GDP improved a bit for a brief period and remained stagnant until 1991 (this was the year when the bloody civil war ended and the then military government of the country was overthrown by a coalition of rebel forces). As the result of that instability in the country there was further fall in GDP per capita in 1992; but after the end of the civil war, the new government in power adopted new Economic Reform Programme with the help of international financial institutions (International Monetary Fund (IMF) and World Bank). The development strategy adopted was called Agricultural Development Led Industrialisation (ADLI). Following the economic reform the country had shown decent growth until the country went in to full scale war with Eritrea in 1998. Consequently the country had experienced negative growth in those war time periods.

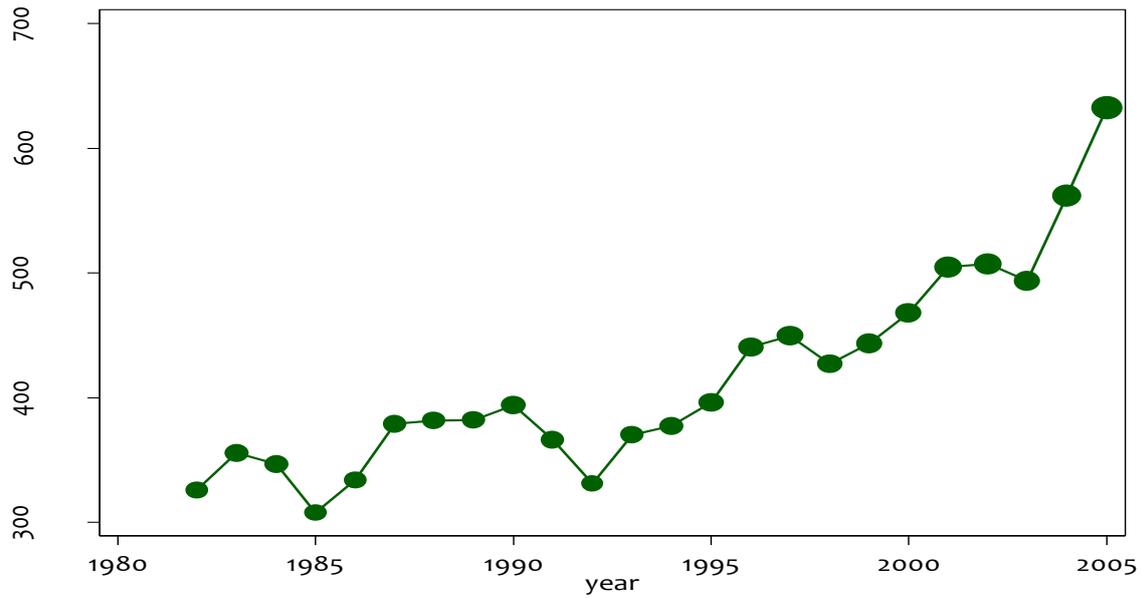


Figure (3): Ethiopian GDP Per Capita at PPP overtime

In 2002/03, there was drought in most parts of the country which led to another year of bad harvest and negative growth. In between 2003/04 and 2009/10 the country has been growing at annual average of 11percent which makes Ethiopia one of the fastest growing economies in Sub-Saharan Africa countries and tops the list among non-oil economies (Ethiopian Ministry of Finance and Development, 2009/10).

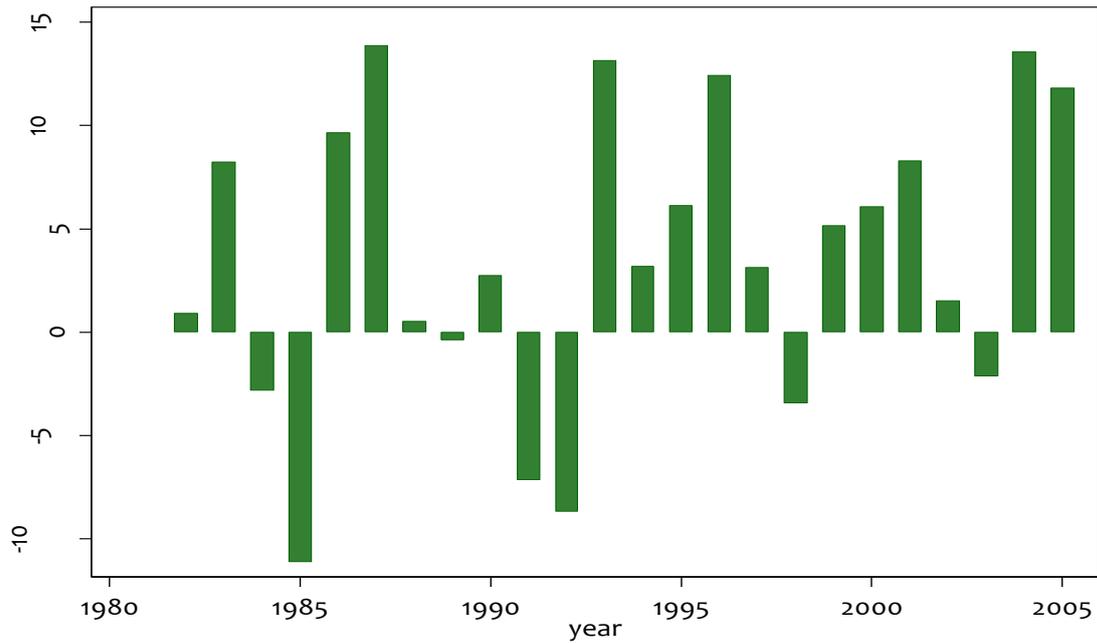


Figure (4): Ethiopian Growth per capita between 1980 and 2005.

#### 1.4. Objective of the Study

The main objective of the study is to see how macroeconomic conditions in the country affect child health with special emphasis to infant. The specific objectives of the study include:

- To look in to the general trend of infant mortality in Ethiopia
- To analyse how macroeconomic conditions and cost of living affect infant mortality
- To investigate the other micro-level determinants of the persistently high mortality observed in the country

#### 1.5. Organization of the Paper

The paper is organized as follows. Section two summarises the relevant theoretical as well empirical works, this is followed by the conceptual framework. Section three basically discusses econometric modelling; the descriptive statistics and data sources are presented under section three. Results and discussions are presented in section five. In the last section conclusion and policy implication are discussed.

## 2. LITERATURE REVIEW

There has been extensive empirical as well as theoretical works conducted on the determinants of infant and child mortality. Caldwell and McDonald (1982) on maternal education and infant and child survival in Nigeria, Pritchett and Summers (1996), Ezra and Kirso (2002) on the effect of birth interval on infant mortality in Ethiopia; Ezra and Gurum (2002), Mutunga (2007), Agha (2000), Masset and White (2003). Some empirical works look into the macroeconomic effect of mortality with special emphasis to infant mortality; to mention some Schady and Smith (2009), Paxson and Schady (2005), Dehejia and Lleras-Muney (2004), Baird, Friedman and Schady (2009) and others. On the theoretical part, Mosley and Chen (1984) and Schultz (1984) propose analytical framework to study child survival from different perspectives.

### 2.1. Theoretical Formulation

#### 2.1.1. Macroeconomic Volatility and Mortality

There are different channels through which country's national income or per capita income (macroeconomic conditions) may affect infant and child mortality in particular and health in general. The first association is a direct and positive one between income per capita and infant and child survival. The richer the country is the more resources it will allocate in order to protect its infant and child. More resources will be directed to investment in health sector which makes health easily accessible for all citizens. Anand and Ravallion (1993) elucidate the channels through which income affects general well being and health. One of the explanations is the capability expansion through economic growth i.e. the general public will have greater command over the relevant goods and services like food, health care, medical services, basic education, and so on-which in turn leads to improved health and nutrition, and (hence) lower rates of mortality and higher life expectancy as the result of increase in average income in the economy. The second explanation is capability expansion through provision of social services. Following economic growth, there will be provision of essential goods and services- clean drinking water, sanitation, health care, epidemiological protection, elementary education, and so on-leads to improved social outcomes. Growth only matters if it is used to finance suitable public services (Anand and Ravallion, 1993). The third one is capability expansion through poverty reduction. Social outcomes (health in general) will be improved if income poverty is reduced.

The other way in which national income affects mortality rate among infants and child works through its impact on fertility rate and maternal education.

In developing countries, macroeconomic shocks (measured by decline in GDP per capita which is predetermined variable for households have negligible control) may lead to change in consumption pattern of the households; following the macroeconomic downturn, households consume less nutritious foods, and will cut their private expenditure on infant and child health inputs, including preventive health care or medical attention for children who are ill. This means as pointed out by Schultz (1984) there will be fall in the demand for health inputs for infant and child by the households. If the GDP contraction turns out to be severe, then it might lead to further contraction in public health expenditure (Baird et al; 2011).

According to modernization theory (which is one of the five theories that explain determinants and variation of infant mortality in less developed countries) industrialization and then economic development promotes living standards of the population and leads to the fall in infant mortality. It emphasises that economic growth is the driving force behind economic development within countries. As the economy grows, it will lead to industrialization and urbanization thereby living standards improve. As the result of improved living standards, people will have access to medical care which may lead to the fall in infant mortality in particular and mortality in general.

The other channel through, which economic growth or GDP per capita influences infant mortality works via fertility and maternal education. As formulated by Becker (1981), the demand for children by couples depends on households' income just like any other normal goods which in turn according to Anand and Ravallion (1993) argument depends on the general economic condition in the country. Of course the magnitude of the income parameter in the demand for children function depends on also other cultural and social factors. Therefore when macroeconomic condition gets worse, then couple will decide to postpone birth leading to the fall in birth rate in such times (Hojman, 1994). In Schultz's theoretical framework, in addition to the standard medical inputs as determinants of child health output, birth order of the child, the preceding birth interval, total number of children ever born to the couples and mother's age at birth are important determinants. So the general economic condition impacts the level of mortality via its impact on the birth rate.

It is also true that as the economy grows, female participation in the labour market might increase. This leads to higher opportunity cost for child bearing; as a result there might be fall in birth rate as the economy improves. At the same time, whenever mothers participate in the labour market, then the quality of children (health of the children) may deteriorates since higher children quality might be achieved by mothers staying at home and taking personal care of the children (Hojman, 1994), this is indeed one of the intermediate inputs to infant and child health

(Schultz, 1984; Mosley and Chen, 1984). In line with this argument, the social modernization theory (which is one of the variants of modernization theory) stresses that when females are more educated and active in the labour market, there will be reduction in fertility rate and higher birth spacing which lead to the fall in mortality rate. Besides this maternal education induces to behavioural changes related to breast feeding and child health care practice and health service utilization (Christian, 2008 pp 92).

## **2.2. Empirical Literature Review**

### **2.2.1. Micro-level Studies on Infant Mortality**

Caldwell and McDonald (1982) examine the impact of maternal education on infant and child survival using Nigerian data. This study confirms the importance of parental education especially mother's education for the observed reduction of infant and child survival in Nigeria and the authors find that this finding is also true for a wide range of other developing and emerging countries; the impact of parental education is probably greater than the combined effects of income (or wealth) and access to health facilities; and in addition to that rural-urban mortality differentials become small once parental education is controlled for. As Caldwell and McDonald (1982) argue, the massive reduction in infant and child mortality observed before 1970's was not only the result of technological and economic changes but also the result of social changes of which parental education played significant role for the improved infant and child survival rate.

Agha (2000) investigates the determinants of infant mortality in Pakistan using household level data. Household poverty increases infant mortality; food availability as measured by the proportion of total expenditure spent on food has a significant impact on infant survival. Crowding living condition also increases the risk of dying of infants. Besides these factors, household level socioeconomic determinants like mothers and fathers' education and maternal age at birth, preceding birth interval are found to be important determinants of infant mortality.

Using Kenyan Demographic and Health Survey data, Mutunga (2007) look at the household's environmental and socioeconomic characteristic (which include maternal education, access to safe drinking water, sanitation facilities and others) determinants of infant and child mortality using survival analysis framework. Child survival rate is observed to be higher in affluent households which have better housing condition, better nutrition access and better education; so these households will have higher demand for health care which will enhance survival probability of infant and child. And it is found that in those households with higher family size infant and child mortality is lower. Mutunga's findings are consistent with Agha (2000).

Pandey et al (1998) investigate the unadjusted effects (not controlling for other demographic factors) of socioeconomic characteristics of infant and child mortality in India using survival analysis. They find that mortality tends to be higher among those children born to illiterate mothers, born in rural areas and have no access to sanitation facility and access to mass media information. But the effect of these socioeconomic factors becomes small when other demographic variables are included.

To investigate the effect of birth interval on child survival, Ezra and Gurum (2002) use community and family survey data from Southern Ethiopia and they find out that for those children who are breastfed, birth interval isn't a crucial problem. Nonetheless they also confirm that short preceding birth intervals are associated with higher risk of dying and mortality is higher especially in the first year of life.

Ezra and Kiros (2000) examine households' vulnerability to food crisis and its implication on the incidence of deaths in Ethiopia using primary survey data. What they find is that mortality in times of drought and famine among children (under age 4) was highest and mortality in general is very high. Vulnerable households suffered more deaths due to hunger.

Arulampalam and Bhalotra (2006) investigate whether the state dependence (or scarring) hypothesis of infant mortality works using micro data from India. Their finding proves that there is indeed scarring effect in most of the Indian states meaning that there is a strong causal effect of a child death on the risk of death of the subsequent child in the same family which is identified after controlling for observed and unobserved family heterogeneity. In those states which are relatively affluent and advanced in socioeconomic terms (Punjab and Kerala), scarring effect is found to be weak. When an infant dies, then mothers stop breastfeeding and conceive sooner than otherwise which might expose to high risk of death for the child to be born for it is born after short birth interval.

In order to analyse the effect of privatization of water service provision on child mortality in Argentina, Galiani et al (2005) use matching estimator<sup>2</sup>. The finding implies that the variation in ownership of water service provision across time and space led to the fell in child mortality in areas where the water service was privatized. The reduction in mortality rate following water

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<sup>2</sup> In case of non-experimental studies of programme evaluation, matching estimator is the preferred and most widely used method to estimate the average effect of a programme intervention. Basically matching compares the outcome of the programme participants with those of matched non-participants. Matching between the participants and non-participants is carried out based on the observed similarity of the observation. Galiani et al (2005) apply matching estimator to examine the impact of privatization of water provision services by comparing those regions which privatized the service with those which didn't.

service privatization was associated with reductions in deaths from infectious and parasitic diseases and uncorrelated to deaths from unrelated to water conditions.

In their meta-analysis of determinants of child health and nutrition, Charmarbwala et al (2004) find that income a central variable in the determinants of child health nutrition. Households spend much on food and health when they have much resource available so income will have a negative and significant impact on mortality. But the meta-analysis result shows that insignificant t-statistic on income for infant mortality whereas it has a significant t- statistic for child mortality. Birth order (which is marginally significant), birth interval, parental education in general and maternal education in particular have statistically significant impact on infant mortality.

### **2.2.2. Macroeconomic Condition and Infant Mortality Studies**

To analyse the impact of economic fluctuations on child mortality in pre-industrial Sweden, Bengtsson (1999) combines long macroeconomic time series data with micro data on individual level. He has found out that economic fluctuations do impact mortality among children above age one; it has also a strong lag effect on child mortality. He also comes up with an intriguing finding that infant mortality appears to be unrelated to economic fluctuation; and unable to confirm the hypothesis that different occupational groups have different infant mortality as a result of breast feeding practices. Low level of infant mortality, according to Bengtsson, is mainly due to under registration of deaths at that age group. Compared to any other age group, infants are less vulnerable to economic fluctuations and insecurity. Hence infant survival is mainly influenced by variables like their mother's age at birth, birth order, their sex and whether they are breast fed or not.

According to Pritchett and Summers (1996), half a million child death occurred in most developing countries in 1990s was mainly the result of poor economic performance. Pritchett and Summers (1996) study the pure income effect by applying instrumental variable to control for possible reverse causation using cross country data from developing countries. Increase in income indeed leads to better health in terms of improved infant as well as child mortality; they come up with income an elasticity of -0.19 for infant mortality after controlling for education implying that a country at the sample mean would avert 1 death per 1000 if income were 1 percent higher.

By merging individual data records from Netherlands on births, marriage and death certificates from 1815 to 2000 with historical macroeconomic indicators, Van den Berg et al (2006) study the effect of being born in recession on mortality in later life. They find that being born during macroeconomic downturn increases mortality in later life for most of the population. Their

result indicates also that lower social class suffer disproportionately being born in bad economic times implying that there was inequality in mortality in Dutch society during the period under study.

Bhalotra (2007) investigates the impact of macroeconomic shocks on childhood mortality in India using demographic data at the individual level with a panel of state-level data on GDP and other macroeconomic variables by cohort. She finds out that temporary downturns in the economy raise mortality. The impact of cyclical fluctuations vary across different regions of India implying that initial conditions of the particular region such as inequality and other political variables are important. Besides this, the study by Bhalotra (2007) shows that policies that increase growth rate of the agricultural sector will contribute to the reduction in infant and child mortality.

To investigate the impact of macroeconomic shocks on infant mortality rate in Peru, Paxson and Schady (2004) use Demographic and Health Survey (DHS) data with macroeconomic variable (GDP). It is found out that infant mortality increased in times of deep economic crisis in Peruvian case which is attributed to the collapse in both private and public health expenditure in such economic conditions. Consistent with Paxson and Schady (2004) and using Peruvian data, Agüero and Valdivia (2009) find that decline in GDP per capita leads to increase in infant mortality; 1 percent decline in GDP per capita is associated with an increase in infant mortality between 0.30 and 0.39 percent.

In their work on demographic response to economic hardship in pre-industrial Sweden, Dribe et al (2011) find that mortality responds to harvest fluctuations (as measured by fluctuation in grain production) in general and harvest failure in particular. Harvest fluctuation has contemporaneous and lag impact on infant mortality; they find that a 10 percent decline in output led to 1.1 percent increase in infant mortality by the same year and in the following year infant mortality increased by 1.8 percent.

Baird et al. (2011) attempted to investigate the relationship between macroeconomic contractions and infant survival in low and middle income countries. They utilize DHS data with macroeconomic indicator (trend deviation in GDP per capita) from all countries included; they find that there is indeed strong, significant and statistically robust relationship between GDP per capita fluctuation and infant mortality rate. Very large and negative deviation from the trend output (national income) has the greatest harmful impact. In developing countries, whenever there is negative economic shocks, infant especially girls are more likely to die.

Dehejia and Lleras-Muney (2004) study the relationship between unemployment rate at the time of baby's conception and parental characteristics, parental behaviour and child health. They come up with a finding that infants conceived at the time high unemployment rate have a reduced incidence of low and high birth weight, and lower post-neonatal mortality. The improvement in health outcomes during the recession are attributed to improved health behaviour.

A study by Schady and Smith (2009) reveals that in most middle income countries, infant mortality appears to be procyclical or acyclical. In their paper, Schady and Smith (2009) use Demographic and Health Survey from 17 middle income countries to revisit the relationship between aggregate income shocks and infant mortality. Aggregate macroeconomic shocks have income and substitution effects on child health; so if households are constrained by credit, then households may be forced to spend less on health augmenting goods. On the other hand, there is substitution effect that as wages fall, the opportunity cost faced care givers in carrying out time-intensive activities that benefit the children such breastfeeding, cooking healthy meals and others also falls. Therefore the overall effect of aggregate economic shocks on infant health depends on which effect dominates.

### **2.3. General Conceptual Framework**

Mosley and Chen (1984) propose analytical framework for the study of child survival that incorporates biological and social variables together. Under Mosley and Chen's theoretical framework, social and economic determinants of infant and child survival operate through the biological (which Mosley and Chen call them 'proximate factors') mechanism. These proximate determinants of child survival can be grouped in to five i.e. factors related to the mother (age at birth, birth parity and birth interval), environmental contamination, nutrient deficiency, injury and personal illness control. All these factors are function of individual and group behaviour: nutritional practice, hygiene, infant care, fertility pattern and attitudes towards diseases. The operation of the proximate determinants on child and infant health status measured by basically mortality and how macroeconomic conditions affect is shown below. It is the extended version of Mosley and Chen's framework that incorporates macroeconomic conditions.

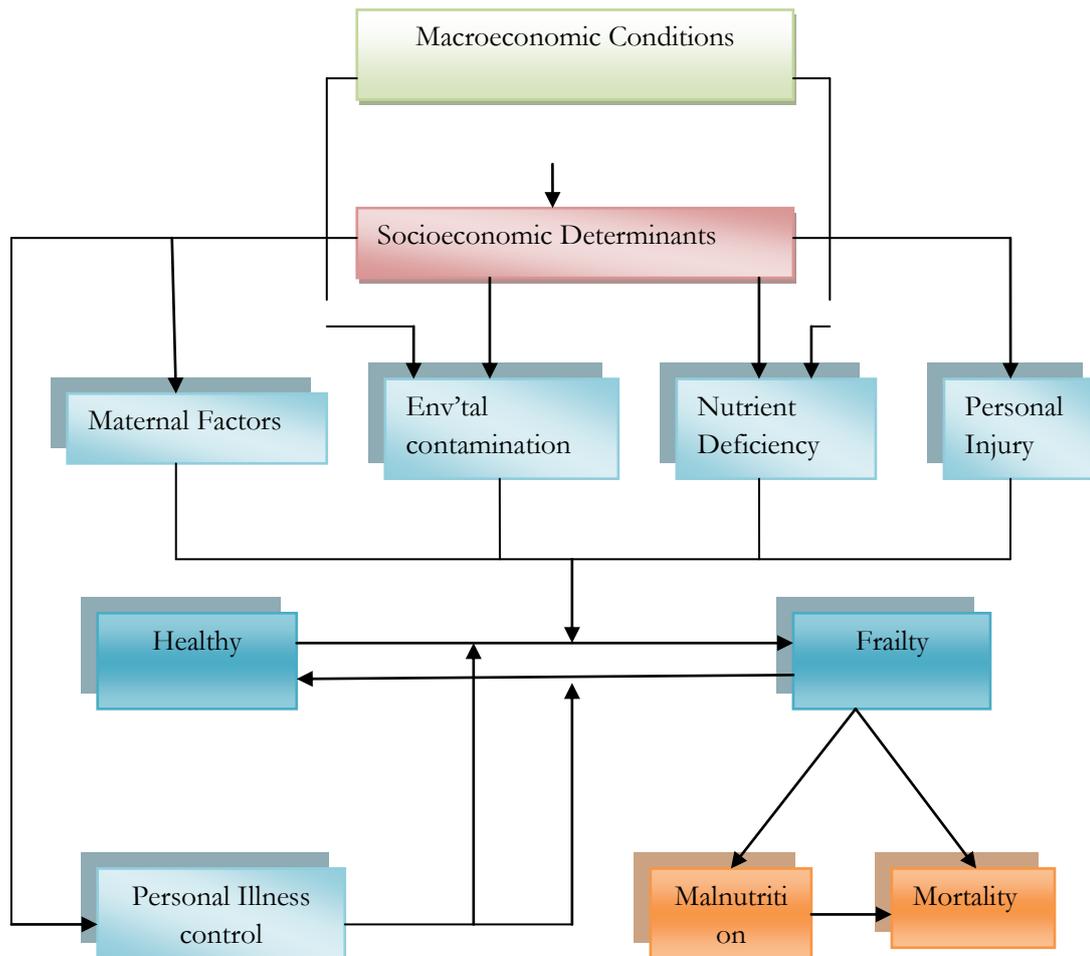


Figure (5): Conceptual framework of the operation of intermediate (proximate) factors and their socioeconomic determinants of infant and child mortality (after Mosley and Chen, 1984)

As illustrated above in the figure, the socioeconomic factors (family income or wealth, parental education) affect infant survival via the proximate determinants. Almost all these proximate factors of child survival may be influenced directly or indirectly by the macroeconomic condition of the country (UNICEF, 1990; Anand and Ravallion, 1993). In UNICEF's (1990) framework, economic structure shapes the political and ideological superstructure of the economy. And these structures in turn determine the available resources and control human, economic and organizational set up. Households' food security, health services and care for children and women are affected by the available information and education which are determined by the economic and organizational set up of the national economy. As Anand and Ravallion (1993) point out economic growth can affect health in general through provision of essential public services (like food, health care, medical services, basic education, and others) which fall either under the socioeconomic determinants or nutrient deficiency in Mosley and Chen's framework, and economic growth can also lead to public provision of essential goods and services like safe

drinking water, access to sanitation facilities, modern health care, and epidemiological protection which most of them fall under environmental contamination factors .

Maternal factors (also called biological factors) include maternal age at birth, parity, length of preceding birth interval and birth order. Mortality is observed to be higher among children born after short preceding birth interval. Such association between preceding birth interval and mortality works through physical and nutritional depletion of mothers (Masset and White, 2003; Bicego and Boerma, 1993). Mother's age at birth is believed to have inverted 'U' shape relationship with infant mortality; infant mortality tends to be higher among those born to younger and older mothers. The reproductive system deteriorates with age so mortality may be higher among infants born to older; on the other hand mortality is higher among children born to younger mothers because these mothers may not fully manage to have birth (Masset and White, 2003). It appears to be the case that mortality among first born infants is high; this is basically because most mothers give their first birth before reaching physical and reproductive maturity (Sullivan, 1994 in Masset and White, 2003).

The second proximate factor under Mosley and Chen's framework is environmental contamination which reflects the various channels through which diseases spread. The effect of environmental contamination can be incorporated using different proxies like incidence of infectious diseases, respiratory disease. But for simplicity, it can also be handled by using access to toilet facility or access to safe drinking water.

The socioeconomic determinants which influence mortality through the proximate ones include those variables which are related to couples productivity (like education) and couples' wealth or income and some community level variable (access to health facilities in the areas).

Maternal education which might affect infant and child mortality through different channels falls under the socioeconomic category. In his classic paper, Grossman (1972) points out that the productivity and effectiveness of health inputs (the proximate determinants of health) improve as mothers are more educated which in turn leads to more demand for health services. Schultz (1984) lists additional distinct ways that mother's education may affect child health. When mothers are educated, they will have more information and they can allocate health resources in optimal way; therefore their children are healthier compared to those children born to mothers with no education or less educated. The preference of the couples for child health, family size and life style in general may be influenced by maternal education. There is also other channel i.e. there is direct association between household income and education level of the couples

(Schultz, 1984). On the other hand, fathers' education is the key determinant of household's ownership of asset and marketable commodities the household consume. Therefore fathers' education mostly affects child health through income effects (Mosley and Chen, 1984). Just like mothers' education fathers' education may influence preferences in the choice of consumption goods and child care.

Other key household level variable is income or wealth. Wealth influences child health through its effect on households' ability to have the minimum nutritious foods, clothing, proper housing, hygienic/preventive care and others. Access to information through television, radio, newspapers is crucial for the households to get relevant information about proper nutrition, hygiene, contraception and immunizations (Mosley and Chen, 1984).

Physical access to proper and modern health facilities also determines child health. It is a common practice to proxy physical access to modern health facility by rural-urban residence status of the households.

### 3. ECONOMETRIC MODELLING

#### 3.1. Child Health Demand Function

In economic modelling of determinants of child health, the starting point is to derive the demand function for child health which is estimable. Becker (1981) is the pioneer in modelling the demand for child health; but here I have adapted Currie's (2000) model. According to this model, couples are assumed to maximize an intertemporal utility function of the form:

$$= \sum_{t=0}^T E_t \left( \frac{1}{1+\sigma} \right)^t U_t + B(A_{T+1}) \dots\dots\dots(1)$$

Where  $\sigma$  is the discount rate,  $B$  is the bequest function,  $A$  is asset and  $U_t$  is utility given as follows:

$$U_t = U(Q_t, C_t, L_t; X_t, u_i, \varepsilon_{it}) \dots\dots\dots(2)$$

Where  $Q_t$  is the stock of child health,  $C_t$  is the consumption of other goods,  $L_t$  is leisure,  $X_t$  is a vector of exogenous taste shifters,  $u_i$  is individual specific taste shifters and  $\varepsilon_{it}$  is shock to preferences.

The parents, as per this model, maximize the above intertemporal utility function subject to total labour constraint, any unearned income and the behavioural health and nutritional production functions.

$$Q_t = Q(Q_{t-1}, G_t, V_t; Z_t, u_2, \varepsilon_{2t}) \dots\dots\dots(3)$$

$$C_t = Y_t - P_{gt}G - \Delta A_t \dots\dots\dots(4)$$

$$Y_t = I_t + w_t H_t + r A_t \dots\dots\dots(5)$$

$$L_t + V_t + H_t = 1 \dots\dots\dots(6)$$

The first constraint (equation 3) is health production function where  $G_t$  is material input to health,  $V$  is time health input,  $Z_t$  is exogenous productivity shifters,  $u_2$  and  $\varepsilon_{2t}$  are individual permanent shifter and productivity shock respectively.  $Y_t$  is total income of the household,  $P$  is price,  $I_t$  is unearned income,  $w_t$  is the wage rate,  $H$  is hours of paid work, and  $r$  is interest rate. Given couples utility function subject to the constraints, we can derive the demand function (the Marshallian demand function).

$$Q_t = Q(Q_{t-1}, X_t, V_t, w_t, P_t, Z_t, u_2, \varepsilon_{2t}, u_i, \varepsilon_{it}) \dots\dots\dots(7)$$

The demand for child health  $Q_t$  is a function of exogenous taste and productivity shifters, price of inputs, wage rate, individual permanent shifter and productivity shocks. This demand function (eqn. 7) is estimable. Here the question is ‘what are these taste and productivity shifters that enter in to the health demand function?’ Currie (2007) point out that mothers and fathers’ education, household income (wealth) and access to information are the important productivity shifters that enter in to the demand function above in equation (7). Past investment or disinvestment in health also determines present child health stock which indicates that parental health related behaviours are determinants (MacInnis, 2004). These parental health behaviours can in turn be related to maternal age at birth whereas sex of the infant is one of the individual *permanent* shifters.

The other variables which enter in to the demand function are family income, price level, wage rate and interest rate; these variables in turn respond to general economic condition of the economy. Ravallion (2001) argue that the poor in developing countries do *share* in gains from rising aggregate income and in losses from aggregate contraction. This suggests that macroeconomic contraction or expansion does impact household income.

In the theoretical framework of Mosley and Chen (1984), the exogenous variables in the above demand function falls in any of the five proximate determinants or may fall under socioeconomic determinants of child health. Here in this study, the emphasis is to investigate the determinants of infant mortality and how macroeconomic condition affects mortality. Rising or contracting GDP can enter in the demand function as an argument through its impact on household income (or the socioeconomic factors in general), environmental factors and nutrient deficiency. On the other hand inflation can enter directly in to health demand function as argument.

In the literature of infant and child mortality, it is customary to use either of the binary response models (logistic or probit regressions) in which case  $Q_t$  takes a zero one value indicating whether the infant dies before age one or not. But using either probit or logistic regression though simple to apply has its own limitation; infants who are not fully exposed to the risk of death (for 12 months) have to be dropped from the sample. For example those who are less than one year age old at the time of the survey (censored observation) can’t be included in infant mortality analysis because we don’t know whether these infants die before celebrating their first birthday or not. For this reason, I have used duration model in which case the entire sample can be used because this model takes censoring in to account for those observations that are not fully exposed.

### 3.2. Survival Analysis

In duration analysis, the hazard functions and survival functions are the crucial part. The time length in which a subject (infant in this case) remains in the original state (alive in infant mortality literature) is referred to as duration (basically denoted by  $T$  which has some distribution in the population).

Then the cumulative distribution function (CDF) of the duration,  $T$ , is defined as:

$$F(t) = P(T \leq t), \quad t \geq 0 \quad \dots\dots\dots(8)$$

Given the cumulative distribution function of  $T$ , the survivor function which is the probability of surviving past time  $t$  can be derived as:

$$S(t) = 1 - F(t) = P(T \geq t) \quad \dots\dots\dots(9)$$

Then density function of the duration  $T$ ,  $f(t)$  is the first derivative of the cumulative distribution function with respect to time  $t$  i.e.  $f(t) = \frac{dF(t)}{dt}$  provided that the cumulative distribution function is differentiable.

For  $h > 0$ ,

$P(t \leq T < t+h/T \geq t)$  will give us the probability of dying in the interval  $[t, t+h)$  given that the infant survived up to until time  $t$ . The hazard function for  $T$  (which is the instantaneous rate of dying per unit of time) is defined as:

$$\lambda(t) = \lim_{h \downarrow 0} \frac{P(t \leq T < t+h/T \geq t)}{h} = \lim_{h \downarrow 0} \frac{F(t+h) - F(t)}{h} * \frac{1}{1 - F(t)} = \frac{f(t)}{1 - F(t)} = \frac{f(t)}{S(t)} \quad \dots\dots\dots(10)$$

Since the first derivative of the survivor function,  $S(t)$ , with respect to time  $t$  is minus of the density function of  $T$ , then the hazard function can be rewritten as:

$$\lambda(t) = -\frac{\log S(t)}{dt} \quad \dots\dots\dots(11)$$

Given that the cumulative distribution function at  $t=0$  is zero, the CDF be written as:

$$F(t) = 1 - \exp\left[-\int_0^t \lambda(s) ds\right], \quad t \geq 0 \quad \dots\dots\dots(12)$$

Once we have the CDF of T expressed as a function of the hazard function,  $\lambda(t)$ , then we can differentiate it to get the density function of T,  $f(t)$  as

$$f(t) = \lambda(t) \exp\left[-\int_0^t \lambda(s) ds\right] \dots\dots\dots(13)$$

So all probabilities can be computed using the hazard function

### 3.2.1. Hazard Function Conditional on Time-Varying Covariates

Here in this study, I want to model the effect of time varying covariate (the macroeconomic variable i.e. GDP per capita) and time invariant variables (characteristics of the infant and demographic variables related to the mother and the household). Hence the hazard function should be specified conditional on this time varying variable and other time invariant variables. The conditional hazard function at a particular time t when there is one or more time varying regressors looks like:

$$\lambda[t; X, z(t)] = \lim_{h \downarrow 0} \frac{P[t \leq T < t+h / T \geq t, X, z(t+h)]}{h} \dots\dots\dots(14)$$

And the proportional hazard with time varying covariate is given by:

$$\lambda[t; X, Z(t)] = \exp\{X' \beta + [\gamma Z(t)]\} \lambda_0(t) \dots\dots\dots(15)$$

Taking the logarithm of the above proportional hazard model will be simplified as:

$$\log \lambda[t; X, Z(t)] = X' \beta + [\gamma Z(t)] + \log \lambda_0(t) \dots\dots\dots(16)$$

Where  $\log \lambda_0(t)$  is the baseline hazard common to all units in the population and its estimation is not necessary. Cox(1972) proposes partial maximum likelihood estimator for the coefficients that doesn't require estimating the baseline hazard and doesn't make any assumption about the form of the hazard. The Cox model is referred to as semi-parametric model. Therefore the parameter estimates are obtained by maximizing the partial likelihood function as opposed to likelihood function. The partial likelihood function is given as:

$$L = \sum \log \left[ \frac{\exp(x' \beta + \gamma z)}{\sum \exp(x' \beta + \gamma z)} \right] \dots\dots\dots(17)$$

$$= \sum_{uncensored} (x' \beta + \gamma z) - \log \sum_{censored} \exp(x' \beta + \gamma z) \dots\dots\dots(18)$$

Then we optimize this partial likelihood function to estimate the parameters without specifying the duration dependence.

The interpretation of hazard ratios and the coefficients from the survival analysis is a bit tricky therefore it needs caution. The hazard ratio (which is the exponential of the coefficients) is basically interpreted as odds ratio i.e. say for example for a dichotomous variable *sex* which takes zero when the infant is male and one when the infant is female, the hazard ratio for the variable *sex* is the relative odds of dying for male compared to female infants. If the hazard ratio for this variable is found to be 0.89, then it means the odds of dying for female is 11 percent less compared to male. In general for categorical variables, the hazard ratio should be interpreted compared to the reference category.

#### 4. DESCRIPTIVE STATISTICS and DATA SOURCES

The study is based on the Ethiopian Demographic and Health Survey data of 2005 which has detail retrospective birth history and other demographic events stretching back to 1970 until 2005. But such retrospective data is susceptible to data collection error. There is higher probability of under-reporting of events like deaths and births especially respondents under report deaths that occur at infancy stage. Such under reporting if it is omitted selectively means that there is lower infant mortality. And it is also true that underreporting of deaths is higher for those who died long ago. There is also significant heaping on age at deaths (deaths at age one are more reported than deaths at other ages). Therefore it needs great caution when we interpret the result. This micro level data is combined with the macro variables (GDP per capita and inflation which are taken from International Monetary Fund, World Economic Outlook Database, 2011).

As can be inferred from table (2), around 82 percent of the infants are born to mothers with no education at all, 13 percent are born to mothers with primary education and the remaining 5 percent are born to mothers with secondary or higher education; this descriptive statistics reveals the low level of maternal education in Ethiopia. *Relatively* fathers' education level is better, about 11 percent of the infants' fathers have secondary or higher education, around 24 percent have primary school and 65 percent don't have any education at all.

When we look at access to information (i.e. whether the household has either television or radio or both or neither), still majority of the infants grow up in a household where there is no media access; around 67 percent don't have access to either television or radio or both. The same is true for electricity access; it is only 11 percent of the infants who are from households with electricity access. In relation to access to safe drinking water (which is considered as environmental contamination indicator), the lion share of the infants (around 79 percent) didn't have safe drinking water.

In Demographic and Health Survey (DHS) data, there is no household income or consumption variable, instead there is wealth index constructed based on Principal Component Analysis using the information about dwelling characteristics and households ownership of consumer durable goods (e.g., flooring material, roof material, number of rooms in relation to household size, type of drinking water source, and toilet type). This index takes five values (poorest, poorer, middle, richer and richest) in the DHS dataset. But for simplicity I redefine it to take three values (poor, middle income and rich). So based on this measure, around 46 percent of the infants are from

poor households, 19 percent from the middle income and the remaining 35 percent are from rich households.

The sex composition is that 52 percent of the infants included for this study are male and 48 percent are female. Almost majority of the infants are singletons i.e. 98 percent are single and less than 2 percent are twins. Mother's age at the respective birth ranges between 15 years to 49 years old with the mean age at birth of 25 years.

The variable religion takes three values that indicate the religion of the household. About 58 percent of the infants are from Christian family, 39 percent from Muslim households, and less than 3 percent of them are from other religion.

Higher proportions of infants are born after a long interval. It was only 12 percent born within the first eighteen months of the preceding birth, 38 percent are born in between 18 and 36 months and around 50 percent of the infants are born after 36 months of the preceding birth interval.

Following Bhalotra (2006), the macroeconomic variables (GDP per capita and inflation which are both in log) are introduced in to the analysis as the weighted average of GDP per capita over the relevant exposure period where the weights are the fraction of infant's life spent in each year. (For example, if a child is born in September 2000, then the relevant exposure period for this infant is four months in 2000 and 8 months in 2001. Given this, the macro variable for this child is the weighted average of 2000 and 2001 GDP per capita where the weights attached are one-third and two-third respectively). Both GDP per capita and inflation variables are detrended using HP filter<sup>3</sup>. Over the whole study period (1980-2005), the actual mean GDP per capita (at PPP) is around USD \$450.

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<sup>3</sup> To detrend the GDP and inflation series, HP filter is used instead of the centred moving average. And the weighted average for the relevant exposure period for both GDP and inflation is taken after the series are detrended i.e. the series are first detrended and then the weighted average based on the exposure period is calculated.

**Table (1): Descriptive Statistics for Micro level Variables**

Variable	No. of Obs	Mean	Stan. Dev.	Minimum	Maximum	Percent
<b>Mother's educ</b>						
No education	22,154	-----	-----	-----	-----	81.8
Primary educ	3,627	-----	-----	-----	-----	13.4
Secondary or above	1,303	-----	-----	-----	-----	4.8
<b>HH media access</b>	<b>27,084</b>	<b>0.33</b>	<b>0.47</b>	<b>0</b>	<b>1</b>	
No media	18,033	-----	-----	-----	-----	66.6
Has access	9,051	-----	-----	-----	-----	33.4
<b>Access to safe water</b>	<b>26,806</b>	<b>0.204</b>	<b>0.403</b>	<b>0</b>	<b>1</b>	
No Access	21,311	-----	-----	-----	-----	79.5
Has Access	5,495					20.5
<b>HH electricity</b>	<b>26,882</b>	<b>0.109</b>	<b>0.311</b>	<b>0</b>	<b>1</b>	
No electricity	23,956	-----	-----	-----	-----	89.1
Has electricity	2,926	-----	-----	-----	-----	10.9
<b>Father's educ</b>		-----	-----	-----	-----	
No education	17,651	-----	-----	-----	-----	65.3
Primary educ	6,360	-----	-----	-----	-----	23.5
Secondary or above	3,018	-----	-----	-----	-----	11.2
<b>HH wealth</b>						
Poor HH	12,404	-----	-----	-----	-----	45.8
Middle Income	5,022	-----	-----	-----	-----	18.5
Rich HH	9,658	-----	-----	-----	-----	35.7
<b>Religion</b>						
Christian	15,785	-----	-----	-----	-----	58.3
Muslim	10,532	-----	-----	-----	-----	38.9
Others	767	-----	-----	-----	-----	2.8
<b>Sex of the infant</b>	<b>27,084</b>	<b>0.479</b>	<b>0.499</b>	<b>0</b>	<b>1</b>	

Male	14,092	-----	-----	-----	-----	52.0
Female	12,992	-----	-----	-----	-----	48.0
<b>Twin or Single</b>	<b>27,084</b>	<b>0.17</b>	<b>0.13</b>	<b>0</b>	<b>1</b>	
Single	26,612	-----	-----	-----	-----	98.2
Twin	472	-----	-----	-----	-----	1.8
<b>Mother's age</b>	27082	24.8	6.4	15	49	100
<b>Birth Interval</b>						
<=18 months	3,331	-----	-----	-----	-----	12.3
Between 18 and 36	10,154	-----	-----	-----	-----	37.5
36+ months	13,599	-----	-----	-----	-----	50.2
<b>Birth Order</b>						
1 <sup>st</sup> -3 <sup>rd</sup> born	16,219	-----	-----	-----	-----	59.8
4 <sup>th</sup> -5 <sup>th</sup> born	5,884	-----	-----	-----	-----	21.7
6 <sup>th</sup> – 7 <sup>th</sup> born	3,175	-----	-----	-----	-----	11.7
8+ born	1,806	-----	-----	-----	-----	6.6
<b>Residence</b>	<b>27,084</b>	<b>0.109</b>	<b>0.312</b>	<b>0</b>	<b>1</b>	
Urban	2,969	-----	-----	-----	-----	10.9
Rural	24,115	-----	-----	-----	-----	89.1
<b>Breast Feeding</b>	<b>26,476</b>	<b>0.94</b>	<b>0.233</b>	<b>0</b>	<b>1</b>	
Never	1,520	-----	-----	-----	-----	5.8
Breastfed	24,856	-----	-----	-----	-----	94.2

<sup>4</sup>Source: Author's computation based on Ethiopian Demographic and Health Survey of 2005.

For the categorical variables, it is only the percentage presented.

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<sup>4</sup> Due to some missing values in the DHS dataset, there are different numbers of observation for different variables. For example, for the variable *access to electricity*, there are some not de jure residents included in the study so there is no response for about whether they have access to electricity or not. Hence I recoded such responses as missing. That is the reason why there are different number of observations.

**Table (2): The Descriptive Statistics for the Macroeconomic Variables Over time (1980-2005)**

Macro Variable	Year Covered	Mean	Std Dev.	Min	Max
Actual log_GDP	1980-2005	6.066	0.281	5.686	6.781
Log_GDP Dev.	1980-2005	0.000	0.087	-0.163	0.212
Log_GDP Trend	1980-2005	6.066	0.260	5.708	6.570
Actual log CPI	1980-2005	4.253	0.493	3.491	5.254
Log CPI Dev.	1980-2005	0.000	0.113	-0.222	0.225
Log CPI Trend	1980-2005	4.253	0.479	3.450	5.029

Source: International Monetary Fund (World Economic Outlook Database, 2011)<sup>5</sup>

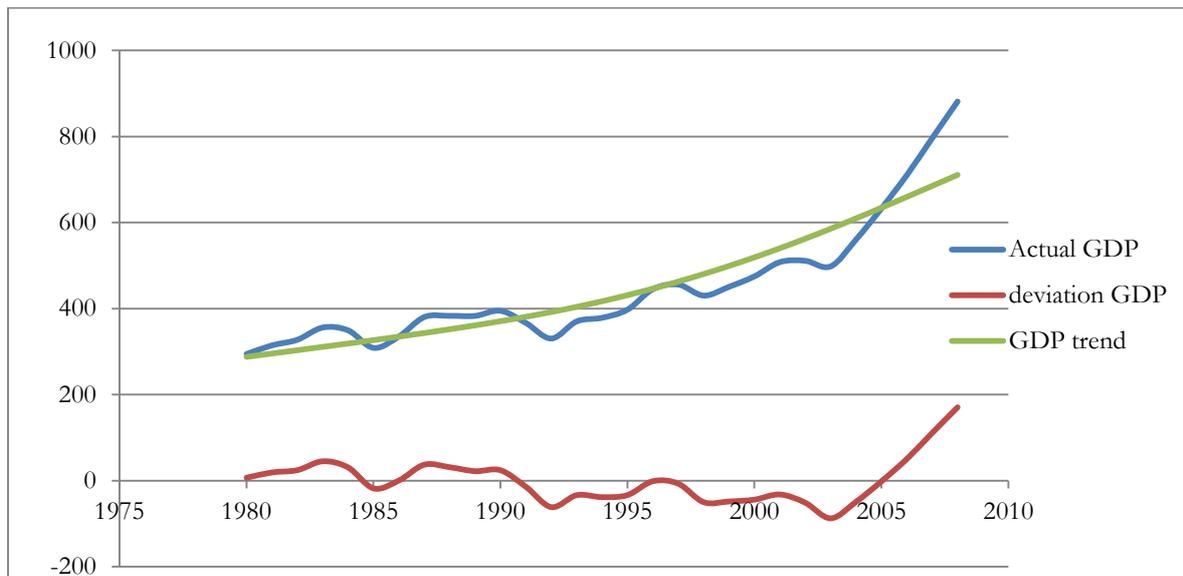


Figure (6): The detrended annual GDP series starting from 1980 until 2008.

### Urban-rural Infant Mortality<sup>6</sup>

The Ethiopian Demographic and Health Survey data shows that there exists rural-urban differential in infant mortality; in rural area infant mortality is about 89 died before celebrating

<sup>5</sup> The earliest GDP series available for Ethiopia is only from 1980.

<sup>6</sup> Infant mortality differential between urban and rural residence, by sex of the infant and mothers education given above is bivariate analysis

their first birthday out of 1000 live births where as in urban areas it is only 51 per 1000 live births.

### **Infant mortality differential by Mother's education**

Infant mortality is higher among those mothers with no education compared to those with primary and higher education. Among mother's with no education at all, infant mortality rate is around 88 died before reaching age one per 1000 live births, infant mortality among children born to mothers with primary education is about 83 per 1000 on the other hand among children born to mothers with secondary or higher is only 39 per 1000 live births.

### **Gender Differential**

In a society where there is male preference (like in India and China), mortality among female children is much higher than that of male (Maitra, et al, 2006,). But in Ethiopia, it is found that mortality among female infant is lower compared to those of male infants; among female infants, it is 73 per 1000 live births whereas among male infants it is 96 per 1000 live births.

### **Regional Difference**

The lowest infant mortality is observed in the capital, Addis Ababa, which has around 40 per 1000 live births; on the other hand Amhara, Gambela, Benshangul-Gumuz and Southern Peoples regional state have relatively higher infant mortality (above 90 per 1000) compared to the capital Addis Ababa. Surprisingly those regions with majority of their populations are pastoralists (Somali and Afar regional states) have lower mortality compared to those mentioned above; for example in Somali regional state infant mortality rate is found to be around 64 per 1000 live births.

## 5. RESULTS and DISCUSSION

The result from the proportional hazard model is presented in table (2). The robustness of the model specification is checked. Besides the robustness of the model, I test for the equality of survivor function among different groups using log-rank test. The chi-squared test statistic from log rank test is given in Appendix (2).

In general, all the demographic, environmental and socioeconomic factors have the expected effect. But the effect of the macro variable i.e. log of GDP per capita is found to be insignificant and has unexpected sign at least in the context of developing countries. A positive coefficients of GDP per capita (0.08) and hazard ratio greater than one (i.e. 1.08) implies that increasing GDP per capita will lead to increasing infant mortality that is not the case in most developing countries. But when consumer price index (CPI) is used instead as indicator of macroeconomic condition, it is consistent with the expectation and previous empirical works in developing countries. (The coefficients from the Cox proportional hazard model can be found at the appendix). The coefficient of CPI is positive and the hazard ratio is greater than one which means that when the cost living increases, living condition gets deteriorated and as the result mortality tends to increase in such bad economic times that is consistent with expectation and previous empirical works in developing countries (Bhalotra, 2007; Schady and Smith, 2009). The unexpected sign of GDP per capita, I suppose, may be because of the fact that Ethiopia is an agrarian economy where more than 85 percent of the labour force is employed; it is bad harvest that have immediate and direct impact on the fertility and mortality. Therefore GDP per capita may not really reflect the macroeconomic condition in such pre-industrial society. Annual rainfall by region could be good candidate as proxy for harvest condition which can precisely reflect the harvest condition. Since agriculture in Ethiopia is rain fed, harvest condition is responsive to rainfall. The insignificant effect of macroeconomic condition on infant mortality could also because of less vulnerability of this group to economic insecurity as Bengtsson (1999) finds in pre industrial Sweden. Bengtsson argue that infant survival is dependent more on behavioural variables (like breast feeding) and maternal factors (mothers' age at birth, birth order) and sex of the infants instead.

**Table(3): Hazard Ratio from the Cox-Proportional Hazard Model**

Variables	Haz. Ratio	Std. Err.	Z Value	Haz. Ratio	Std. Err.	Z Value
Macroeconomic Indicator						
Inflation	1.04	0.03	1.41	-----	-----	-----
GDP per capita	-----	-----	-----	1.09	0.05	1.06
Twin	4.27***	0.59	10.42	4.28	0.59	10.45
Media	0.88	0.07	-1.60	0.88	0.07	-1.62
Female	0.83***	0.05	-2.92	0.83	0.05	-2.93
Breast feeding	0.83	0.15	-1.03	0.83	0.15	-1.04
Safe water	0.89	0.09	-1.17	0.89	0.09	-1.17
Electricity	0.67**	0.13	-2.05	0.67	0.13	-2.06
Residence	0.92	0.17	-0.43	0.92	0.17	-0.44
Birth order						
1 <sup>st</sup> -3 <sup>rd</sup> (Ref)	-----	-----	-----	-----	-----	-----
4 <sup>th</sup> -5 <sup>th</sup>	0.70***	0.07	-3.53	0.70	0.07	-3.56
6 <sup>th</sup> -7 <sup>th</sup>	0.63***	0.09	-3.25	0.62	0.09	-3.31
8+	0.55***	0.12	-2.83	0.54	0.11	-2.92
Mother's educ						
No educ	-----	-----	-----	-----	-----	-----
Primary	0.96	0.10	-0.42	0.96	0.10	-0.40
Sec or high	0.84	0.23	-0.65	0.84	0.23	-0.64
Father's educ						
No educ(Ref)	-----	-----	-----	-----	-----	-----
Primary	0.82***	0.07	-2.34	0.82	0.07	-2.33
Sec. or high	0.70***	0.11	-2.37	0.70	0.11	-2.36
Religion						
Christian (Ref)	-----	-----	-----	-----	-----	-----
Muslim	1.12	0.10	1.35	1.12	0.10	1.35
Others	0.82	0.17	-0.99	0.82	0.17	-0.97
Region						
Tigray(Ref)	-----	-----	-----	-----	-----	-----
Afar	0.52***	0.11	-3.13	0.52	0.11	-3.12
Amhara	1.24	0.16	1.60	1.24	0.16	1.60
Oromia	0.90	0.13	-0.77	0.90	0.13	-0.77
Somali	0.51***	0.10	-3.33	0.51	0.10	-3.32
SNNP	0.93	0.16	-0.42	0.93	0.16	-0.41
Benshangul	1.51***	0.20	3.20	1.51	0.20	3.21
Gambela	1.47**	0.26	2.20	1.48	0.26	2.21
Hrari	1.03	0.23	0.15	1.03	0.23	0.14
Addis Ababa	1.26	0.40	0.73	1.25	0.40	0.71
Dire Dawa	1.20	0.26	0.86	1.20	0.26	0.85

Wealth						
Poor (Ref)	-----	-----	-----	-----	-----	-----
Middle	0.98	0.09	-0.25	0.98	0.09	-0.24
Rich	0.97	0.09	-0.33	0.97	0.09	-0.34
Birth Interval						
<18 mon(Ref)	-----	-----	-----	-----	-----	-----
b/n 18 &36	0.48***	0.04	-9.55	0.48	0.04	-9.59
>36 months	0.47***	0.04	-8.55	0.47	0.04	-8.56
Mothers age bir	0.84***	0.03	-4.84	0.84	0.03	-4.80
Mothers age^2	1.00***	0.00	4.11	1.00	0.00	4.05
No. children	1.12***	0.02	5.96	1.12	0.02	6.16

**Source:** Author's computation based on the Ethiopian Demographic and Health Survey (2005)

**NB.** The reference categories for the categorical variables are indicated as (ref.).

\*\*\* p<0.01, \*\*p<0.05 and \*p<0.1 indicates the level of significance

Consistent with Bengtsson's (1999) argument the most important determinants for infant survival in Ethiopia are found to be the micro-level variables. The hazard ratio for the dummy variable 'twin' is found to be highly significant and the risk of dying among twins as expected is much higher than those of singleton, it is 4 times higher than those of singleton. It can also be inferred from the positive sign of the coefficient of 'twin' that being twin increases the hazard of dying. The log rank test also confirms that the survivor function for singleton and twin is different.

Access to mass media as measured by households' ownership of either television or radio is believed to play crucial role in improving infant survival for it enables households to get information about proper nutrition, hygiene and other child health inputs. Consistent with expectation and empirics, mortality is higher among children born in a household with no information access. The risk of dying among children in a household with media access is around 13 percent lower as can be inferred from the hazard ratio of 0.87. Like media access, access to safe drinking water and access to electricity in the household has negative effect on infant mortality. Compared to those with no access to safe water, those with access to safe drinking water have higher probability of survival. The hazard ratio for those with no safe water is 11 percent higher.

One of the behavioural health inputs in addition to nutrient intakes and use of medical services is breast feeding. Infants who have never been breastfed tend to experience higher risk of dying. The hazard ratio for those who have been breast fed is 17 percent less than those of who have

never been. It has also the case that those infants residing in urban areas have higher probability of survival. In most developing countries like Ethiopia, health facilities concentrate in urban areas. Meaning that those born in rural areas don't have access to modern health facilities and then the risk of dying for those infants is high i.e. it is 8 percent higher than those born in urban areas.

The probability of surviving is much higher among female children. The hazard ratio for female dummy is 83 percent which is highly significant even at 1 percent level of significance which implies that male infants have 17 percent higher probability of dying compared to their female counterpart. And the Kaplan-Meier survival graph by sex supports this finding.

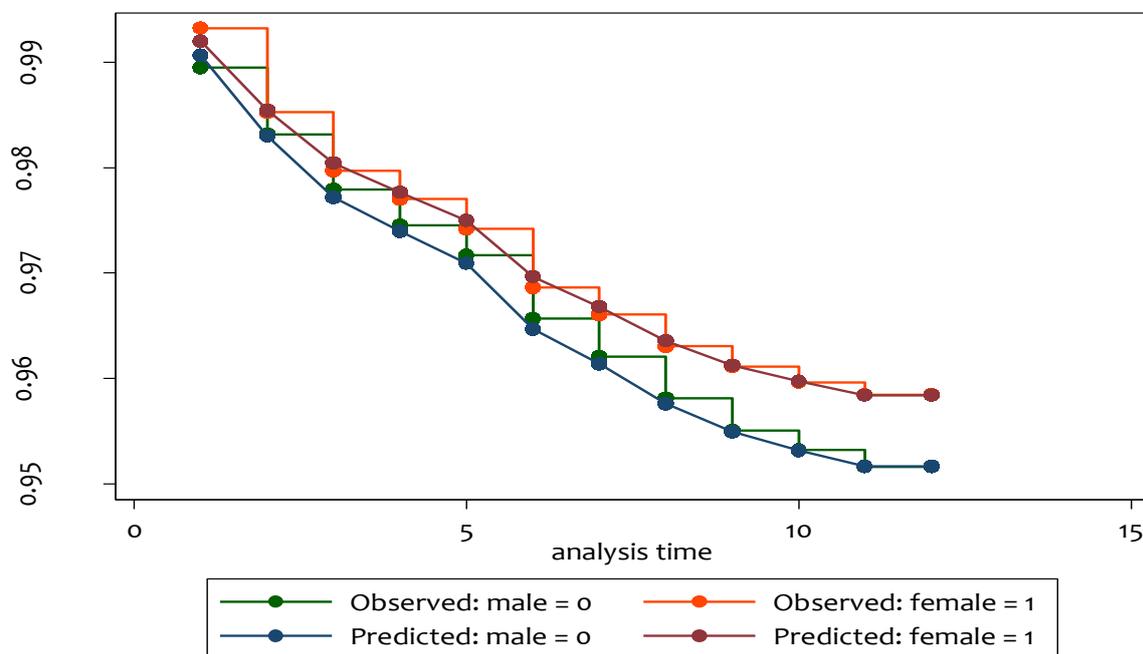


Figure (6): Kaplan-Meier Survival Plot by Sex of Infants

The other important socioeconomic variable for infant and child mortality is maternal education. This variable is treated as a categorical variable that assumes three values (i.e. no education at all, primary education and the last category is secondary or higher education). The reference category for estimation in our case is no education i.e. the hazard ratios for the other category are interpreted compared to the reference category. Compared to those infants born to mothers with no education, those born to mothers with primary school have a higher survival rate; the risk of dying for the latter group is 5 percent less. And when mothers have secondary or higher educations, then children born to these mothers have lower risk of dying compared to the reference category. The hazard ratio for this group is 83 percent indicating that the risk of dying

for the group is 17 percent less. This can easily be seen from the Kaplan-Meier survival graph (shown below) by mother's education. The survival probability of children born to more educated mothers compared to those born to less educated mothers is higher

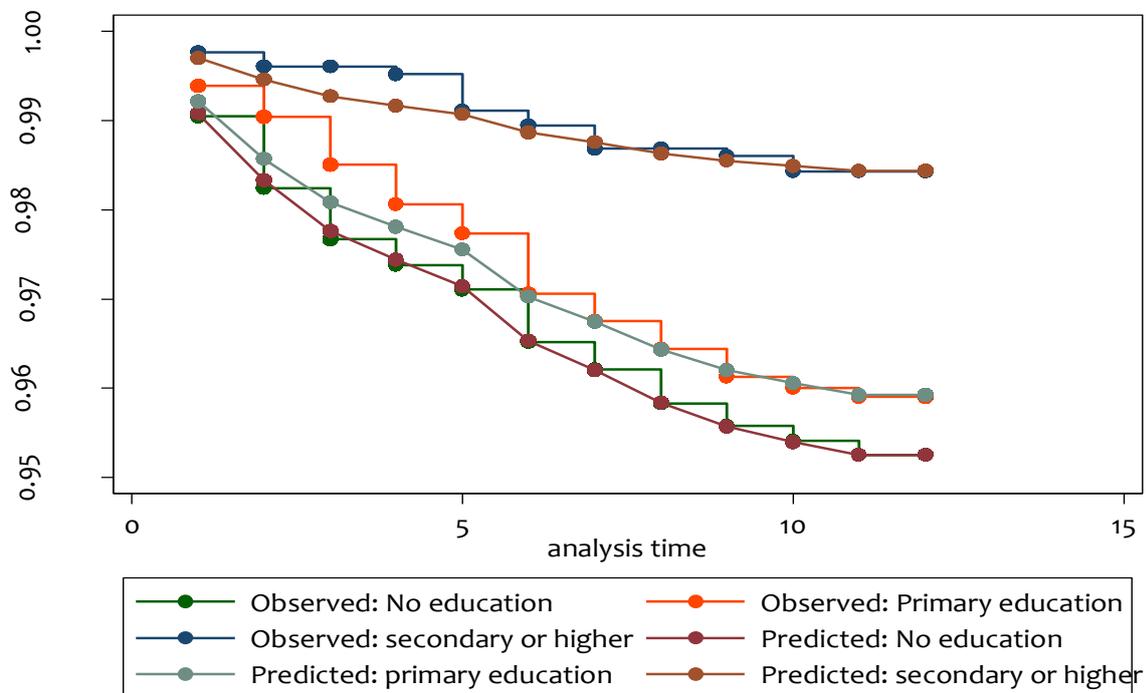


Figure (7): Kaplan-Meier Survival Graph by Maternal Education

Like mother's education, the level of fathers' education has impact on infant mortality. The effect of this variable may work through its impact on income. More educated fathers earn more and this may influence the nutritional intake of the infants which in turn increases the probability of survival.

Preceding birth interval which is treated as categorical variable has negative effect on infant mortality. The reference category in the estimation is those infant with preceding birth interval less than 18 months. Infants born after short birth interval have higher risk of dying; this is due to the physical and nutritional deterioration of mothers (Messet and White, 2003). The risk of dying among those born in between 18 and 36 months is 52 percent less than those born within 18 months of birth interval. Consistent with Rutstein (2005) the probability of survival for those born after 36 months of birth interval is almost the same as those born in between 18 and 36 months. All the hazard ratios and coefficients of birth interval are found to be highly significant.

The negative sign of the coefficients of birth interval indicates that born after 18 months of the preceding birth decreases the risk of dying.

Birth order which has somewhat not clear relationship with mortality shows that those born at higher order tend to have a higher rate of survival. Those first born infants have higher risk of dying compared to those born at higher order. In line with the regression result the test for the equality of survival function shows that there is statistically different survival function among infants of different birth order. The number of children in the households has positive and significant effect on infant mortality contrary to the finding by Mutunga (2007). But the total number of children in the household indicates the dependency ratio in the household. Hence it is expected that mortality (especially infant for they are vulnerable) increases when there are more dependents because members will compete for the available resources.

To test for the inverted 'U' shaped relationship between mother's age at birth and infant mortality, the square of mother's age at birth is included as explanatory variable in the regression analysis. As expected, the coefficient of mother's age have a negative sign whereas the square term has a positive sign implying that mortality is higher among those children born to younger and older mothers. This indicates the existence of inverted U shape relationship and the coefficients are significant even at 1 percent level of significance.

Infants from richer households have less risk of dying. The reference category in the estimation is poor households. As can be seen in table (2), the coefficients of middle income and rich households are negative revealing the fact those infants from these two category have higher probability of surviving compared to those from poor households. The hazard ratio for middle income infants is 97 percent and for those from richer households is 96 percent; it means that the hazard of dying for those infants from middle income infants is 3 percent less than those from poorer household while those from the richer families have 4 percent lesser probability of dying relative to the reference category. The log-rank test for the equality of survivor functions confirms that the survivor functions for infants from different income groups are different.

Consistent with the bi-variate analysis, the Cox Proportional hazard estimates gives us the same result regarding regional difference. Compared to the reference category (i.e. Tigray regional state), the risk of dying among children born in Amhara, Benshangul-Gumuz and Gambela regional states is higher. Like the result from the bivariate analysis, the risk of dying among infants born in Somali and Afar regional states is lower.

Besides regional difference in the risk of dying, there also exist rural urban differences. The estimation result from the survival analysis shows the odds of dying among infants born in rural areas are higher compared to those born in urban areas. This is an indication that modern health facilities are concentrated in urban areas and in rural areas such facilities aren't easily available.

The log-rank test for the equality of survival function shows that the survival functions of infants from different religion are statistically the same. We are unable to reject the null hypothesis of equality of survival function meaning that the risk of dying among infants from different religion is not different.

This study echoes the previous empirical findings (Masset and White, 2003; Mutunga, 2007; Rutstein, 2005, Caldwell and McDonald, 1982). But the effect of macroeconomic condition on infant survival is found to be mixed for different indicators. When GDP per capita is used as indicator for macroeconomic condition, its effect on infant mortality is positive which is contrary to expectation and some empirical works (Paxon and Schady, 2006, Pritchett and Summers, 1996, Agüero and Valdivia, 2010, Baird et al; 2007, Bhalotra, 2006) in developing countries context. On contrary to this finding, when inflation is used as indicator for the cost of living in the country, the result confirms the previous works and expectation that as cost of living increases mortality tends to increase.

## 6. CONCLUSIONS

This paper empirically explores the impact of macroeconomic condition and infant mortality in Ethiopia after controlling for households' socioeconomic determinants and other 'proximate' factors by combining micro data from Demographic and Health Survey data with macroeconomic variables using duration analysis. The macroeconomic variable is introduced in the micro data as the weighted average of the infant's relevant exposure period GDP or consumer price index. The robustness of the model used is checked against different specification. Besides the robustness of the model, the equality of the survivor function for different groups is tested using log-rank test. The log-rank test for the equality of the survivor function shows that all categorical variables included in the estimation except religion have different survivor function; unable to reject the null hypothesis for religion indicates that odds of dying for infants from different religion are not statistically different.

The effect of macroeconomic condition as measured by log GDP per capita has insignificant and unexpected sign for the coefficient. On the other hand, when inflation is used instead, the sign of the coefficient is found to be consistent with the expectation and previous empirical works though it is not still significant. The hazard ratio for inflation is found to be greater than one implying that whenever there is high inflation in the country, then the risk of dying for the infants also increases or it implies infant mortality rate increases as the cost of living increases.

The household level socioeconomic variables, maternal factors and environmental factors are found to be the important determinants of infant mortality. Among these parental education in general (both mothers and fathers' education), maternal age at birth, children's birth order, preceding birth interval, access to information, access to safe drinking water and access to electricity play crucial role in determining the level of infant mortality in Ethiopia.

Infants born to less educated mothers and fathers have higher odds of dying compared to those infants born to more educated couples. Maternal age at birth has inverted U shape relationship with infant mortality. Mortality is found to be higher among children born to younger and older mothers. Younger mothers may not manage to have birth as the result infants born to these mothers are exposed to higher risk of dying; on the other hand, for older mothers reproductive system deteriorates with age which is consistent with other studies (Masset and White, 2003;)

Multiple births have high risk of dying because such births are exposed to complication at birth. Being twin increases the risk of dying by three folds. Females have higher probability of survival as compared to male infants. The odds of dying among male infants are 17 percent higher compared to female infants.

The behavioural variable i.e. breast feeding increases the probability of surviving. The hazard ratio for the dummy variable *breastfeeding* is 0.75 which shows that there is much lower risk of dying among infants who were breastfed compared to those who had never been breastfed.

Consistent with the bivariate analysis, the Cox proportional hazard model shows that there is indeed regional difference in infant mortality. In regional states like Benshangul-Gumuz, Amhara, Gambela, infant mortality is higher compared to the reference category i.e. Tigray regional state.

The findings from this study implies that government's policy emphasis to combat the high infant mortality should to invest much on education which has repercussion on other areas besides the health sector. In addition to that rural urban infant mortality differential can be addressed by making health facilities easily accessible for rural residents.

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## APPENDICES

**Appendix (1):** The Coefficients estimates from Cox-proportional Hazard Estimation

Variables	Coef.	Std. Err.	Z value	Coef.	Std. Err.	Z value
Macroeconomic Indicators						
Inflation	0.034805	0.024756	1.41	-----	-----	-----
GDP per capita	-----	-----	-----	0.081844	0.048568	1.69
Twin	1.450748	0.139175	10.42	1.453376	0.139064	10.45
Media	-0.13192	0.082405	-1.6	-0.13342	0.082408	-1.62
Female	-0.18487	0.063407	-2.92	-0.18563	0.063409	-2.93
Breast feeding	-0.18351	0.178099	-1.03	-0.18549	0.178116	-1.04
Safe water	-0.11543	0.098689	-1.17	-0.11583	0.09867	-1.17
Electricity	-0.40434	0.197003	-2.05	-0.40505	0.196979	-2.06
Residence	-0.08139	0.188511	-0.43	-0.08338	0.188462	-0.44
Birth order						
1 <sup>st</sup> -3 <sup>rd</sup> (Ref)	-----	-----	-----	-----	-----	-----
4 <sup>th</sup> -5 <sup>th</sup>	-0.35607	0.100742	-3.53	-0.35642	0.100109	-3.56
6 <sup>th</sup> -7 <sup>th</sup>	-0.46773	0.143892	-3.25	-0.47196	0.142787	-3.31
8+	-0.59314	0.209232	-2.83	-0.61028	0.209234	-2.92
Mother's educ						
No educ	-----	-----	-----	-----	-----	-----
Primary	-0.04413	0.103899	-0.42	-0.04129	0.103839	-0.4
Secondary or hi	-0.17649	0.271545	-0.65	-0.17442	0.27154	-0.64
Father's educ						
No educ	-----	-----	-----	-----	-----	-----
Primary	-0.1961	0.083897	-2.34	-0.19563	0.083834	-2.33
Sec. or high	-0.3629	0.153195	-2.37	-0.36129	0.153226	-2.36
Religion						
Christian (Ref)	-----	-----	-----	-----	-----	-----
Muslim	0.11659	0.086381	1.35	0.116429	0.086365	1.35
Others	-0.19984	0.201683	-0.99	-0.19572	0.201697	-0.97
Region						
Tigray(Ref)	-----	-----	-----	-----	-----	-----
Afar	-0.65815	0.210119	-3.13	-0.65522	0.209966	-3.12
Amhara	0.213627	0.133212	1.6	0.213739	0.133211	1.6
Oromia	-0.10757	0.140344	-0.77	-0.10748	0.140303	-0.77
Somali	-0.67801	0.203815	-3.33	-0.67626	0.203718	-3.32
SNNP	-0.07346	0.174928	-0.42	-0.07247	0.174931	-0.41
Benshangul	0.413566	0.129272	3.2	0.414719	0.129229	3.21
Gambela	0.386879	0.175993	2.2	0.388746	0.175972	2.21
Hrari	0.033085	0.221973	0.15	0.031268	0.221942	0.14
Addis Ababa	0.229664	0.31599	0.73	0.225015	0.315988	0.71
Dire Dawa	0.18322	0.213314	0.86	0.180906	0.213326	0.85
Wealth						

Poor (Ref)	-----	-----	-----	-----	-----	-----
Middle	-0.0217	0.087527	-0.25	-0.02111	0.087532	-0.24
Rich	-0.03043	0.092922	-0.33	-0.03198	0.092912	-0.34
Birth Interval						
<18 mon(Ref)	-----	-----	-----	-----	-----	-----
b/n 18 &36	-0.73405	0.076899	-9.55	-0.73667	0.076837	-9.59
>36 months	-0.74571	0.087256	-8.55	-0.74489	0.08698	-8.56
Mothers age bir	-0.17356	0.035896	-4.84	-0.17191	0.035817	-4.8
Mothers age^2	0.002765	0.000673	4.11	0.002724	0.000672	4.05
No. children	0.109232	0.018321	5.96	0.112143	0.018217	6.16

Source: Author's computation based on the Ethiopian Demographic and Health Survey (2005)

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

**Appendix (2):** Log-rank test for the equality of Survivor Function

Null Hypothesis: The Survivor Function for different groups is equal

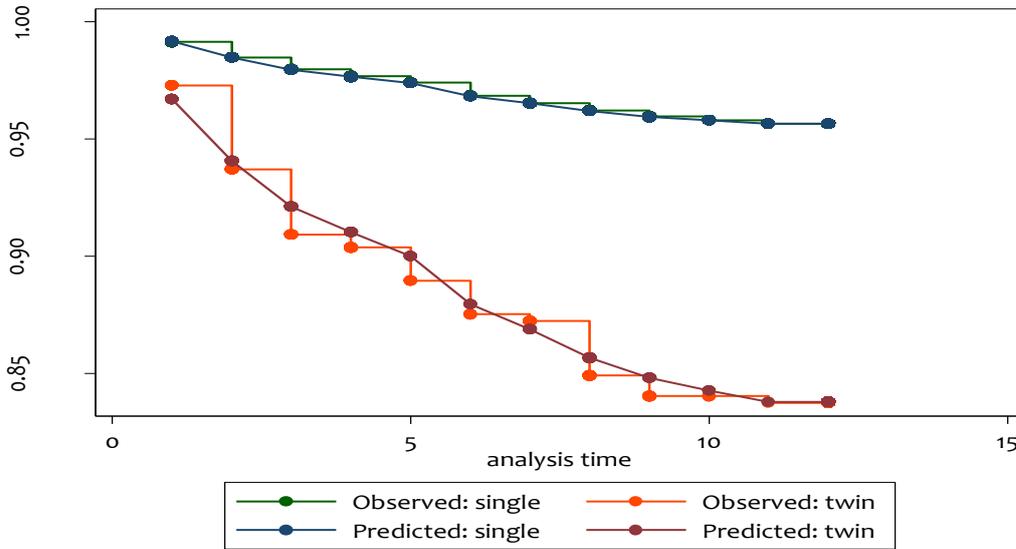
Variables	$\chi^2$ Test Statistic	$Pr > \chi^2$
<b>Twin</b>	123.86***	0.000
<b>Female</b>	6.67***	0.0098
<b>Media</b>	21.29***	0.000
<b>Breast Feeding</b>	6.81***	0.0091
<b>Electricity</b>	35.55***	0.0000
<b>Residence</b>	29.89***	0.0000
<b>Birth Interval</b>	143.15***	0.0000
<b>Birth Order</b>	7.50**	0.0577
<b>Mother's education</b>	28.68***	0.0000
<b>Father's education</b>	38.38***	0.0000
<b>Religion</b>	0.58	0.7498
<b>Region</b>	55.06***	0.0000

NB. The stars indicate that we reject the null hypothesis of equality of the survivor function. So in all cases except religion, we reject the null. In case of religion we are unable to reject the null implying that the survivor functions across different religions aren't different.

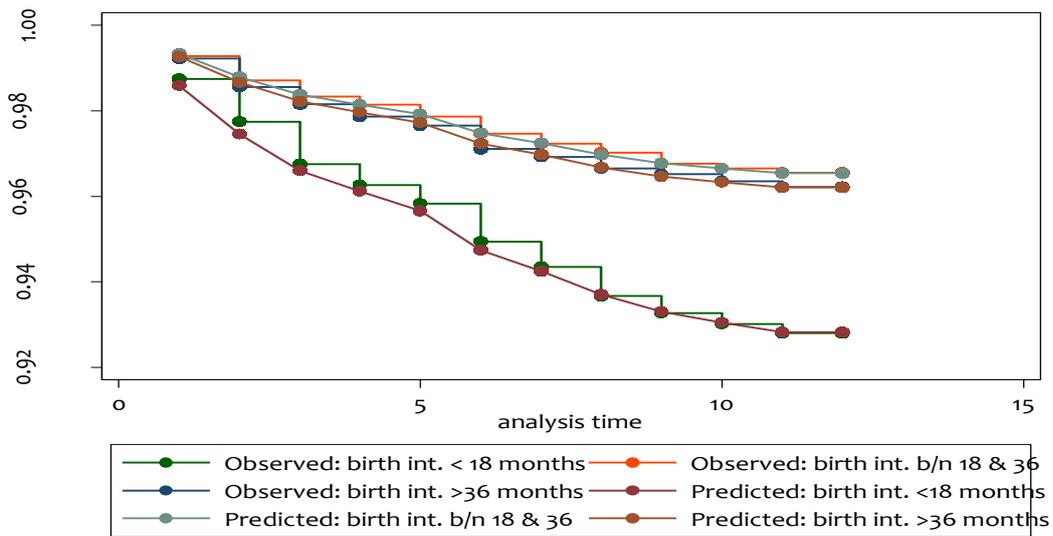
**Appendix (3):** Life Table constructed based on the 2005 Ethiopian Demographic and Health Survey

Interval	Beg. Total	Deaths	Lost	Survival	Std. Error	[95% Conf. Int.]	
1970 1971	27084	0	2	1	0	.	.
1971 1972	27082	1	3	1	0	0.9997	1.0000
1972 1973	27078	0	5	1	0	0.9997	1.0000
1973 1974	27073	0	15	1	0	0.9997	1.0000
1974 1975	27058	0	12	1	0	0.9997	1.0000
1975 1976	27046	3	26	0.9999	0.0001	0.9996	0.9999
1976 1977	27017	3	33	0.9997	0.0001	0.9995	0.9999
1977 1978	26981	7	42	0.9995	0.0001	0.9991	0.9997
1978 1979	26932	11	59	0.9991	0.0002	0.9986	0.9994
1979 1980	26862	17	67	0.9984	0.0002	0.9979	0.9988
1980 1981	26778	14	124	0.9979	0.0003	0.9973	0.9984
1981 1982	26640	26	117	0.9969	0.0003	0.9962	0.9975
1982 1983	26497	26	169	0.996	0.0004	0.9951	0.9967
1983 1984	26302	25	201	0.995	0.0004	0.9941	0.9958
1984 1985	26076	32	168	0.9938	0.0005	0.9928	0.9947
1985 1986	25876	44	411	0.9921	0.0005	0.9909	0.9931
1986 1987	25421	34	268	0.9907	0.0006	0.9895	0.9918
1987 1988	25119	58	484	0.9884	0.0007	0.9871	0.9897
1988 1989	24577	79	461	0.9852	0.0008	0.9837	0.9866
1989 1990	24037	56	506	0.9829	0.0008	0.9812	0.9844
1990 1991	23475	95	643	0.9789	0.0009	0.9770	0.9806
1991 1992	22737	90	768	0.9749	0.001	0.9729	0.9768
1992 1993	21879	76	826	0.9715	0.0011	0.9693	0.9735
1993 1994	20977	101	979	0.9667	0.0012	0.9643	0.9689
1994 1995	19897	95	896	0.962	0.0013	0.9594	0.9644
1995 1996	18906	114	1325	0.956	0.0014	0.9532	0.9586
1996 1997	17467	107	1127	0.9499	0.0015	0.9469	0.9527
1997 1998	16233	139	1478	0.9414	0.0016	0.9381	0.9445
1998 1999	14616	148	1584	0.9313	0.0018	0.9277	0.9348
1999 2000	12884	163	1715	0.9187	0.002	0.9146	0.9226
2000 2001	11006	102	1252	0.9097	0.0022	0.9052	0.9139
2001 2002	9652	154	1967	0.8935	0.0025	0.8884	0.8983
2002 2003	7531	117	1850	0.8777	0.0029	0.8719	0.8832
2003 2004	5564	125	1745	0.8543	0.0035	0.8473	0.8610
2004 2005	3694	151	1750	0.8085	0.0049	0.7987	0.8179
2005 2006	1793	101	1692	0.7223	0.0092	0.7038	0.7399

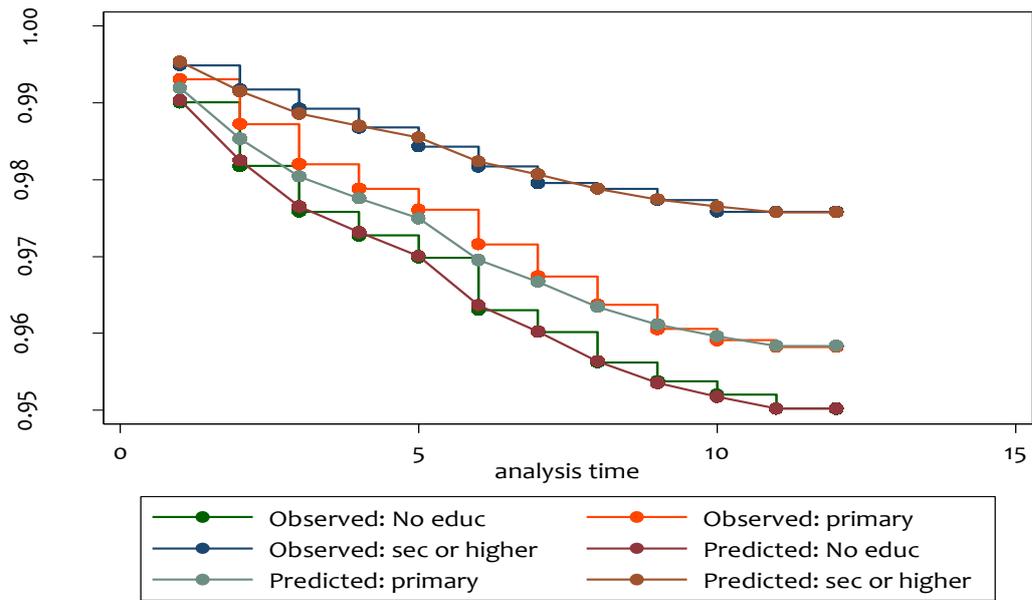
**Appendix (4):** Kaplan-Meier Survival probabilities for selected categorical variables



Kaplan-Meier Survival for twins and singletons



Kaplan-Meier Survival by birth interval



Kaplan-Meier Survival plot by fathers' education

**Appendix (5):** Map of Ethiopia showing the Regional States

