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**THE EFFECTS OF WATER AND SANITATION ON CHILD'S
MORTALITY IN RURAL ETHIOPIA**

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Rural Ethiopia

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Abbreviations

- CDF:** Cumulative Density Function
- CHS:** China Health Survey
- CRM:** Competing Risk Model
- CSA:** Central Statistical Authority
- CSB:** China Statistical Bureau
- ETDHS:** Ethiopia Demographic and Health Survey
- DHS:** Demographic and Health Survey
- GDP:** Gross Domestic Product
- GNP:** Gross National Product
- HSDP:** Health Sector Development Programme
- IMR:** Infant Mortality Rate
- MDG:** Millennium Development Goals
- MOH:** Ministry of Health
- NRS:** National Regional States
- PH:** Proportional Hazards
- PHC:** Primary Health Care
- PWW:** Piece Wise Weibull
- SNNRP:** Southern Nations Nationalities and People’s Region
- U5MR:** Under-5 Mortality Rate
- W:** Weibull
- WB:** World Bank
- WHO:** World Health Organization
- WPP:** World Population Prospectus
- WRI:** World Resource Institute

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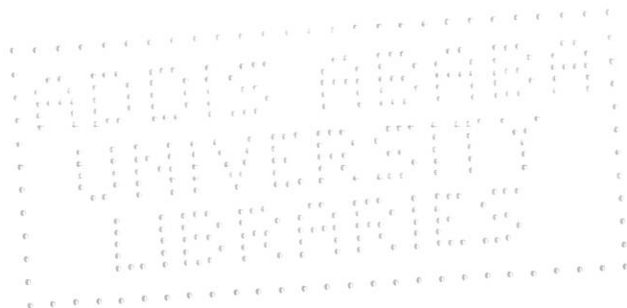
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Abstract

The Ethiopian population is very young, with nearly half (43%) of the population under the age of 15 years. This indicates that there is high potential for future rapid growth of the economy by using this population. Women and children constitute 72% of the population. Like in many developing countries, children under 15 years of age constitute a very large proportion of its population, (43%), of which around 40% are under five and 8% are under 1 years of age. In 2000, the under five-mortality rate (U5MR) was estimated at 166 per 1000 live births (148.6 for urban areas and 192.5 for rural areas), while infant mortality rate was estimated at 97 per 1000 live births respectively. Diarrhea is a major cause of death in infancy and childhood, and it is more common in rural areas where 25% of under five children are susceptible than urban areas where it is only 17%. Currently, the coverage of safe drinking water and latrines remains very low at about or less than 30% and 13% respectively. In rural areas only 4% of children's stool disposed in toilet whereas in urban areas 45% of the children's stool is disposed in the toilet. And 68% of the children's stool in rural areas is disposed outside the dwelling, or thrown in the yard. These low levels of access to safe water and access to excreta disposal are indicators of water and sanitation problems which are believed to be among the major causes of the child's death in the post neonatal and childhood periods. However, the total fertility rate is 5.9 per woman (3.3 for urban and 6.4 for rural) (DHS Ethiopia, 2000), and this implies that there are distinct differences by residence, with rural women having twice as many children as urban women. Thus, the relatively high child mortality, which is in line with the theory of the effect of infant and child mortality on fertility may have led to increased fertility where mothers give birth to many children suspecting that the probability of losing some of them is high.

The National Health Indicators for the year 2003/4 indicate that access to safe water and access to excreta disposal are estimated at 37.5 and 28.9 percent respectively taking a sample of 10 cities in the country (Ministry of Health, 2004). Therefore, the communicable diseases attributable to poor sanitation, and which principally affect the underprivileged sections of the population, are still deemed as the major health problems in Ethiopia.

In line with this, this project investigated the effect of household environmental characteristics, that is, water and sanitation on the probability of child mortality. The analysis is conducted using a Cox Proportional Hazards model. It is a multivariate model of the child's life duration, which analyses the effects of household's environmental characteristics such as water and sanitation on the likelihood of the child's death.

Moreover, the study found that improved water supply results in both infant and child mortality reduction. However, the availability of sanitation facilities per se could not result in mortality reductions unless due attention is given for promoting awareness of the rural society on hygiene practices.

CHAPTER ONE

1. INTRODUCTION

1.1 Background

Ethiopia is the second populous country in Africa with a population of 77.4 million, of which more than 84.2% live in rural areas. 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, Amhara, Oromia, Somalia, Beni-shangul-Gumuz, Southern Nations, Nationalities and Peoples Region (SNNRP), Gambella and Harari, and two Administrative States (Addis Ababa City Administration and Dire Dawa 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 (2005), the proportion of population at the age group 15-64 years is 53.4 %. Total fertility rate is estimated to be 6 children per women (CSA, 2001), which is one of the highest in the world.

Mortality levels are one of the main indicators of living status or development of a population. From 1960 to 2000 global under-five deaths have fallen from 20.4 million to 10.9 million annually. But in Sub-Saharan Africa under-five deaths doubled from 2.3 million to 4.5 million annually. For example, out of the 11 million under-five deaths in 2000, most of them were from Sub-Saharan Africa Countries (UNICEF, 2001).

As is the case in many developing countries, child and infant mortality are unacceptably high in Ethiopia. Under-five mortality rate stands at 166 in the year 2000 per 1000 live births and infant mortality rate was 97 out of 1000 live births. In 1995 these rates were 171 and 116 out of 1000 live births for the under-five and infant, respectively (CSA,2001).

There are numerous causes for infant and under-five mortality that have to be mentioned. But birth related causes, low household income, low parental education, unsafe water, poor sanitation facility, 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.

In Ethiopia, due to recurrent drought, malnutrition is a serious problem. 47% of young children are underweight (CSA, 2001). The health and health related indicators by the Ministry of Health indicate that gastrointestinal, and other infectious and epidemic diseases are highly prevailed (MOH, 2002). Owing to environmental pollution non communicable diseases such as respiratory organs allergy are also the emerging challenges for the country. There is also a lower coverage of immunization service compared even with sub-Saharan African countries (CSA, 2001).

Although in Ethiopia living conditions differ largely between urban and rural dwellers, households living in the rural areas are relatively much poorer than household living in the urban areas. Rural areas of the country have poor access to health facilities, schools, and piped water. The problem of child mortality is therefore most severe in rural areas. In rural areas the under-five year child mortality rates is around 192.5 per 1000 live births, while it is 148.6 for the urban areas. Pandey, Cheo, Luther, Sahu and Chand (1998) suggest that the difference between rural and urban child mortality rates can largely be attributed to better living conditions.

This study focuses on the determinants of child's mortality in the rural areas. More specifically, examining how child mortality is related to the household's environmental and socio-economic characteristics such as mother's education, source of drinking water and sanitation facility is the center of attention. Since this may help in identifying households with high child mortality risks and targeting resources towards those households.

To this end, a hazard rate framework which facilitates the analysis of the determinants of child mortality is used (see Van den Berg, 2001, for a recent survey on duration models). Duration models are easily applicable to the problem of child mortality as this class of models

straightforwardly accounts for problems like right-censoring. The mortality rates depend on many characteristics of the child, the household and the community.

1.2. STATEMENT OF THE PROBLEM

Normally poverty is the problem of Least Developed Countries. It can be defined in various ways. Poverty ridden people are those unable to lead a decent life (Schubert, 1994 cited in Wolday, 2001). This means poverty is pronounced deprivation in wellbeing. In some instances, 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, 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 World Bank (2001) recent estimates disclose that environmental risk factors account for about one-fifth of the total burden of disease in low income countries. WHO (2002) reports that among the 10 identified leading mortality risks in high mortality developing countries, unsafe water, sanitation and hygiene ranked second. In line with the report, unsafe water, inadequate sanitation and poor hygiene habits play a major role in Africa's high child mortality rate. Diarrhea is the third-biggest child killer in Africa after pneumonia and malaria, accounting for 701,000 child deaths out of 4.4 million on the continent every year. It also leaves millions of children with a legacy of chronic malnutrition, the underlying cause of over half of all child mortality. Similarly, the risk of child death in Ethiopia is among higher mortality countries in the World and the highest in the Sub-Saharan Africa (MOH, 2004). This is mainly due to the pervasiveness of poverty the country is experiencing, ill-suited social facilities, chronic drought, and environmental contamination. Seventy five percent up

to eighty percent of the disease burdens in Ethiopia are assumed to be preventable using measures like improving environmental health status and nutritional interventions.

So far, various efforts have been made in relation to environmental health activities in the country since 1950's. For instance, Basic Health Service Provision program, during 1950-1960's, primary health care (PHC) during the 1970-90's, and currently in the Health Sector Development Programmes (HSDP). In spite of all the endeavors, that have been made significant improvement in sanitation status could not have been achieved. This is mainly due to the minimal outcomes subjected to the resources at hand and lack of integration of the concerned stake holders in tackling the problem.

The life support environmental components, designated by air, water, and soil, are the intermediate factors that are potentially deteriorated by human activities. Thus looking for the way to maximize the benefits from our environment has become a basis for our continued survival. All the same, the country is still exerting great effort for the control and prevention of communicable diseases that have been transmitting because of poor living and environmental conditions.

Children's healthy growth and development are the foundation of cognitive and social development. The basic needs for such an achievement are many and interlinked. Chief among which are access to safe drinking water and sanitation. Every child's development is affected by the subtle interaction of its genetic endowment with influences in its physical, social and family environments. Since the basic needs for healthy development are multidimensional, children and families require the concerted action of many sectors to make survival and healthy development a more prevalent outcome (Mehari, 2005).

Thus in this project an attempt is made to analyze the impacts of the household's environmental situations, the socioeconomic conditions and demographic variables on the likelihood of the child's death in rural Ethiopia.

The term sanitation in the narrower and environmental health in the broader contexts are defined as the control of all those factors in man's physical, mental and social wellbeing. It entertains the satisfaction of basic human needs with provisions for basic and healthy housing, drinking water, and waste management in all aspects including personal hygiene (Victor and Earnest, 1995). Above all, it is hard to be glad about the environmental health inputs in the background of sustained burden of diseases existing for many decades. And hence, examining the relationship among environmental, socio-economic, demographic, and child mortality variables is a fundamental task so as to sort out the determining factors and priority areas of intervention. So far little researches have been conducted to disclose the confounding factors of child mortality including socio-economic factors. As a result, the need for the study of this kind is very high both at national and regional levels.

Hence, this study aims at expounding the interaction among the household's environment, socioeconomic characteristics, demographic variables and child's mortality.

1.3. OBJECTIVE OF THE STUDY

The primary objective of the study is to examine the environmental factors associated with infant and child mortality in rural Ethiopia.

The specific objectives of the study can be stated as follows:

- To identify the factors that contribute most to reduce child mortality
- To examine the impact of socio-economic, demographic, household's environment such as water and sanitation on child mortality
- To draw policy implications regarding the household environment and its effect on child mortality

1.4. HYPOTHESES OF THE STUDY

The hypotheses of the study contain:

- There is an inverse relationship between household's environmental characteristics such as water and sanitation and child's mortality.

1.5. SCOPE AND LIMITATIONS OF THE STUDY

The study investigated the effects of environmental, demographic, economic and health related variables on child's survival chances in rural Ethiopia. The reason for selecting rural Ethiopia as study area is that rural areas in Ethiopia are the homes to the marginalized section of the society and social services are inadequate. Moreover, lack of potable water supply and sanitation facilities in the rural area are problems that challenge children's survival. And further rural areas experience higher infant and child mortality than urban areas where there is relatively good health services. As it is the case for any research, this study also encountered an analytical problem that relate to the data set used in the study. That is, information on sources of drinking water and sanitation facilities refers to the time of the survey, but not necessarily to the exposure time of the children unless only recent information was used.

1.6. SIGNIFICANCE OF THE STUDY

In a country like Ethiopia that has poor social conditions (education, housing, sanitation, etc) and with more than 50% of its population illiterate and under the poverty line, the level of communicable diseases is found to be at the highest magnitude.

In studying child mortality socio-economic determinants of disease have been given little attention by biomedical scientists since they primarily focus on disease causing agents. However social scientists seek socioeconomic explanations for diseases noting that the common area, i.e. the environment, should not be overlooked since it is determined by the

socioeconomic factors and it determines the disease causing agents. It is well known that disease occurs due to imbalances caused between man and his environment.

Many literatures on biomedical research show that the agent and host factors of the disease have been identified and studied but the environmental factor of which the child is a part remains an area of little focus. Nonetheless, without knowledge of the environment, it is difficult to prevent or control the disease. Therefore, there is a continuing need to show empirically that environmental health activities associated with socio-economic improvements, organizational readiness to achieve goals, and coordination of efforts among various stake holders, can reduce environmental risks and hence the resulting child death.

Thus, the importance of this study rests on revealing the impact of the socioeconomic, demographic, and environmental variables on child's 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 and environment.

1.7. ORGANIZATION OF THE STUDY

The study organizes as follows chapter one contains introduction, chapter two reviews related theoretical and empirical literatures, chapter three presents the data and methodology employed in detail, chapter four come up with the results obtained and chapter five concludes the findings and provides recommendations based on the analysis undertaken and the results obtained in chapter four.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. THEORETICAL LITERATURE

2.1.1 POPULATION, POVERTY AND THE ENVIRONMENT

Poverty is often associated with degraded rural environments. Environmental degradation has many consequences, because a healthy natural environment sustains non-monetary economies and can be viewed as the "social security" of the rural populations. When the productive functions of healthy rural environments degrade, or when people lose access to those productive environments, movement to cities in search of alternative livelihoods can exacerbate urban poverty. Environmental degradation therefore undermines sustainable livelihoods and affects the rural poor by disproportionately affecting their health, livelihoods and security; and can aggravate poverty in already stressed urban environments.

Current demands, which emanate from population growth, are depleting many of the earth's natural and ecological services (Ehrlich and Ehrlich, 1990; Green, 1992; WRI, 1998). It is likely that those life supporting systems will somehow have to accommodate the additional population as well as support desperately needed advances in living standards for those in poverty, especially half of the world's population living on about \$2 a day (Ahlburg, 1996; WPP, 1999).

People everywhere consume water, food, energy and other natural resources in order to live. All economic activities are based on resources from nature. Any productive activity can deplete natural resources and cause environmental stress. On the other hand, environmental problems can prevent people from reaching an acceptable standard of living (World Vision

Australia, 1998). This is particularly true for poor people, who tend to rely more directly on their environment for survival than the wealthy people.

The impact of humans on their environment is related to population size, per capita consumption and the environmental damage caused by the technology used to produce what is consumed. For instance, between 1950 and 1997 the World's population doubled and the global economy expanded 6-fold. A further modest 2 percent in annual growth in incomes and consumption per capita world wide could result in doubling of consumption every 35 years. This increased consumption, on top of a projected population increase would require economic production to increase (Ehrlich and Ehrlich, 1990; Green, 1992; WRI, 1999). Nonetheless, achieving this without environmental degradation of important life supporting ecosystems is a demanding task.

The rapid population growth in Africa together with lack of clean drinking water and lack of proper human waste treating facilities put much of the population in the continent at risk of water born diseases. Environmental Degradation, declining food security and uncontrolled epidemics of communicable diseases have slowed, and even reversed, the demographic transition to low death rates in the continent, particularly in Sub-Saharan Africa (WHO, 1999).

Malthus, following Robert Wallace, came up with colossal idea that discloses the discrepancy between growth of population and available resources. In his model, Malthus stated that diminishing returns to finite resources inexorably causes a reduction of per capita consumption as the size of population increases. Conversely, the model suggests that fewer people could be made happier if the size of population is reduced. In other words, for Malthus higher population explosion is one of the major factors that exacerbate miseries of mankind.

Then he advocated that human being should practice self restraints and pursue for a self-effacing way of living to control for explosion (Houndroyiannis and Papaetrou, 2002). However, Malthus was against any kind of contraceptive methods since he considered them as evil practices.

Despite his remarkable contributions in the field of population studies, Malthusian theory encountered some drawbacks. Chief among which is that he assumed a way technological advancement and heterogeneities across countries (Jatrana, 1999).

Neo-Malthusians then extended Malthusian theory by incorporating the idea of contraceptive methods. Unlike Malthus, they promoted artificial contraceptive methods. They also had a better understanding on the importance of technological advancement in reversing the arithmetic growth patterns of food production or agricultural outputs. All the same, Both Malthusian Neo-Malthusian theories try to emphasize the intertwined relation that fertility, mortality and economic development have.

High population growth rates that put pressure on the environment contribute to poor health. Poverty causes people to put pressure on the environment while environmental problems cause more suffering among the poor. In the underdeveloped areas resources are meager to fulfill the basic demands of the population. The dependency ratio is very high. Hence, the population is more likely to be malnourished, highly vulnerable to various diseases, exposed to social instability and ill suited social infrastructures that result in high mortality rate. Such complicated relationships among poverty, people and the environment call for environmental protection to ensure our long term survival and wellbeing.

The ability of households, especially poor ones, to obtain appropriate health services, adopt healthy sanitary and dietary practices depends on a variety of factors, including several at the household level. The first of such factors is the role of household finances. Poor households have limited resources at their disposal- not just money and in-kind income, but financial assets and physical assets, such as land and animals (Claeson and et al., 2005). The multiplicity of deprivations that poor people suffer from translates into ill-health. More succinctly, they lack the financial resources to pay for health services, food, clean water, good sanitation, and the other key inputs to produce good health. On the other hand, ill-health, malnutrition, and high fertility are often reasons why households end up in poverty; sink in to it if they are already poor.

The second factor is the role of knowledge. The human asset in the household- knowledge, literacy, and education are important. Knowledge is crucial since lack of knowledge about health issues, which is common in poor households, often leaves members of the household unaware of available health care opportunities and preventive measures (Claeson et al., 2005). The poor also tend to live in communities that have weak institutions and have social norms that are not conducive to good health.

The third factor is the balance of power within households. It is not just the overall level of household resources that matters. In many societies, the balance of power within households is unequal between men and women. Women may have little control over household finances and may play a minor role in decisions about the use of contraceptives to prevent unwanted pregnancy or of condoms to prevent sexually transmitted infections. Mothers may also be constrained in the household when seeking health care for themselves or their children. This unequal power, which may be more pronounced in poorer, less educated households, is a



major risk factor for poor reproductive health outcomes and the poor diet of many women and children (Ibid.).

Precisely, poor people are caught in a vicious cycle, their poverty breeds ill-health; and this in turn conspires to keep them poor.

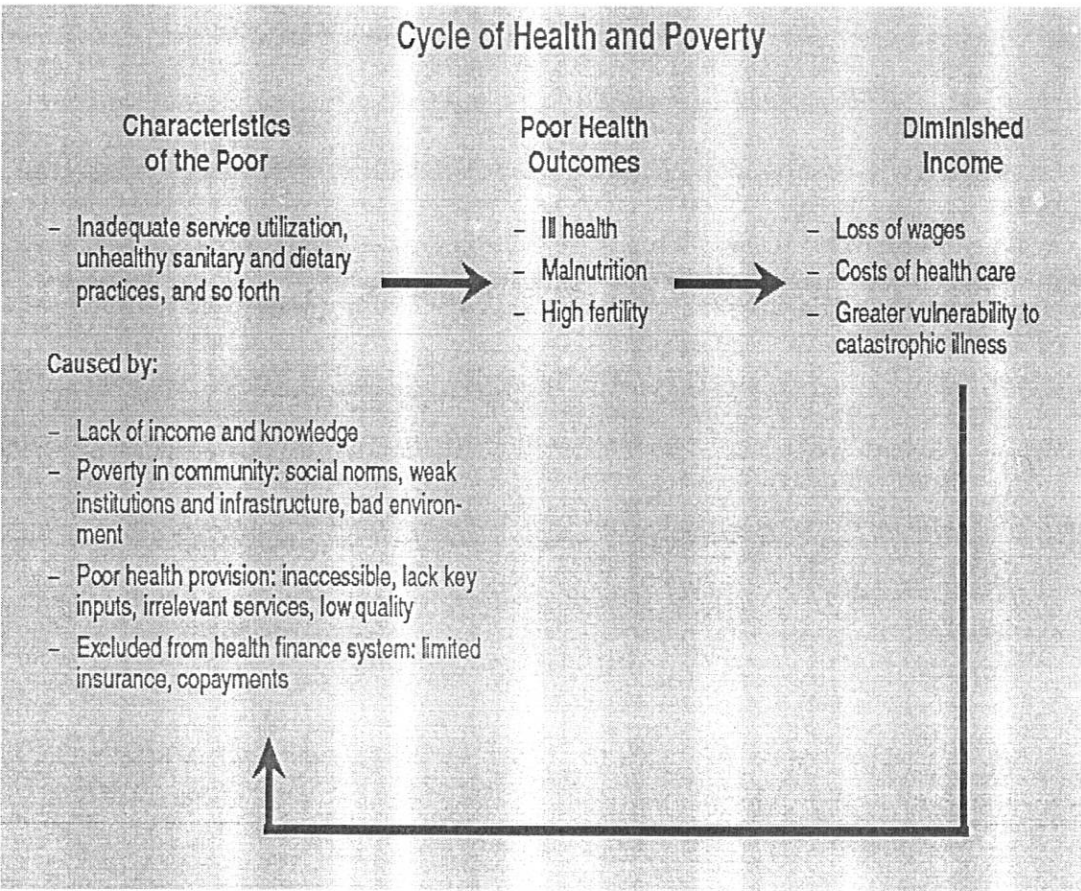


Figure 2.1. Health and Poverty Linkages

(Source: Claeson et al. (2005), Health, Nutrition and Population Chapter 18, p-203)

2.1.2 MORTALITY, FERTILITY AND ECONOMIC GROWTH

Most countries industrialized or not experience important demographic changes. One of the most important of which is the transition from a phase of rapid population growth to one in which population growth is low. Initially, a country experiences a mortality decline and

fertility rises, both contributing to a rise in population growth. This process is known as demographic transition (Houndroyiannis and Papaetrou, 2002).

Modern theories of population relate fertility, mortality and economic development with people's behavior. However, the modern economic theory of population emphasizes the interdependence between infant mortality and fertility in the context of economic theories of behavior (Cigno, 1998; Becker et al. 1999). In Cingo's model reduction in child mortality may either rise or lower fertility. When the level of child mortality is high, reduction in it is likely to raise both fertility and survival enhancing expenditures on children, because it lowers the price of a surviving child. The effect of child mortality reduction at the early state of transition would be to increase the number of surviving children. Many more children therefore survive to productive ages, and begin to earn their keep, thus reducing the cost of their upbringing while also contribute to their families production effort. Feyissa (1984) disclosed that high fertility strains budgets of poor families, reducing the family's resources available to feed, educate and provide health care to children. Recent theories espoused the idea that there is an intermingled relation between fertility and mortality depending on the behavioral pattern of individuals.

Demographers view declines in mortality and fertility as components of a single "demographic transition". There are many competing theories about why fertility declined. One theory that is favored by demographers is that the fertility decline is due to the mortality decline, i.e., it is the response to the improved survival chances of the offspring. An alternative theory proposed by Becker (1981) suggests that the demographic transition occurs since at high levels of income, the adverse effect of the opportunity cost of children on child rearing dominates the positive income effect. This theory, however, is inconsistent with the

simultaneous occurrence of the fertility transition in countries that markedly differed in their levels of income (Kalemli-Ozcan, 2002). Proponents of modern population theories (Houndroyannis and Papaetrou, 2002) argued that there might be a case that fertility may be induced by mortality. When the level of child mortality is higher reductions in it are likely to raise both fertility and survival enhancing expenditures on children, because it lowers the price of a surviving child.

More to the point, as the relationship fertility and mortality have discloses fertility may result in mortality. Since higher fertility can be a signal for narrow birth spacing, parents may not allot enough time to look after their children. Above all, a larger family size with meager resources forces the family to malnourishment, lower health care utilization, use of improper sanitation system and water supply. For this reason, there is a high risk of infant death.

Becker et al. (1999) provides a new theory on the interplay between fertility and economic growth. Unlike Malthus, Becker's theory suggests that fertility will indeed fall as per capita income increases (see Fayissa, 2001). Specifically, he related the demand for rearing children to parental incomes and the cost of rearing children. He also argued that if parents care about their children's happiness rather than their children's existence, they opt to have fewer children so that each one will receive a large inheritance (Fayissa, 2001). This entails that a rise in income, provided the interlinked relation fertility and mortality have, reduces mortality. Mortality decline in turn reduces not only parents' time, energy, emotion and income already invested in the child but also a loss of the anticipated return from the child.

The WHO Commission Report (2001) has examined the links between Macroeconomics and health. The commission observes that "the economic costs of avoidable disease, when taken

together, are staggeringly high”, and that societies with a heavy burden of disease tend to experience severe impediments to economic progress. The report points out that the great ‘take offs’ in economic history (Industrial Revolution in Britain and the rapid growth of Japan in the early 20th century were all supported by improved public health, disease control and greater nutritional intake). Lindhal and Landberg (1994) revealed that economic growth has brought with it improvements in the quality of a number of environmental resources. For instance, the large scale availability of potable water, and the increased protection of human populations against both water –and air born diseases in industrial countries, has in large measure come in the wake of the growth of national income that these countries have enjoyed over the past 200 years or so. Moreover, the physical environment inside the home has improved beyond measure with economic growth (Lindhal and Landberg, 1984).

And further the WHO Commission established that reducing infant mortality is a key to economic growth, for a variety of reasons. Firstly, societies with high rates of infant and child mortality have higher rates of fertility, and large number of children reduce the ability of poor families to invest in health and education, resulting in an under trained, under- skilled productive work force.

In addition to its effect on fertility, child mortality is also important for the human capital investment decision of parents. Lower mortality implies a higher rate of return to education, and thus declining child and youth mortality provides an important incentive to increase investment in the education of each child (Kalemli-Ozcan, 2002). Heckman (2000) also argues that the return to human capital investment is highest before age five. Secondly, lowering infant mortality rates tends to lower, not raise, population growth over the long run, as people adjust to having smaller families (WHO, 2001).

When this happens, the average age of the population rises, and each worker is supporting fewer dependents. Hence this boosts overall per capita GNP (Gross National Product) and economic growth. On the other hand, Becker (1960) suggested that parents tended to increase the expenditure per child rather than the number as income goes up in much the same way that higher income leads consumers to shift towards more expensive automobiles or high priced calories without necessarily increasing the number of cars or calories.

There is evidence of a link between economic growth and infant mortality, and that countries with high infant mortality experience lower economic growth. The WHO commission examined the growth rates of several dozens of countries, with a range of infant mortality between 1965 and 1994. The results obtained show that those which started out with lower infant mortality rates experienced higher economic growth. While those with an infant mortality rate greater than 150 registered an average growth rate of 0.1 percent per year and among countries with the highest infant mortality many recorded negative growth in GDP (Gross Domestic Product) (WHO, 2001).

Concerning Africa, health status appears to explain a crucial part of the difference in economic growth rates. The WHO Commission Report comes up with the recent study which found that more than half of Africa's growth shortfall relative to the high growth countries of East-Asia could be explained by disease burden, demography and geography (Bloom and Sachs, 1998). The Commission therefore concluded that since disease weighs so heavily on economic progress investing in health is a vital component of an overall development strategy. Not only the health sector but also the water and sanitation sectors also have a vital role to play as far as development is concerned.

The Millennium Development Goals (MDGs) are linked with the issue of improving water supply and sanitation services. Specifically, Goal 4: *REDUCE CHILD MORTALITY*,

emphasizes that improved sanitation and drinking water sources reduce infant and child morbidity and mortality

Poverty, disease, inadequate water, and sanitation are in each other's pocket. The sustained contribution of water and sanitation provide the groundwork of health and sustainable development. Most importantly, for people living in poverty, improved water supply and sanitation facilities are not merely means to an end, but they are outcomes of poverty reduction.

2.1.3 THEORETICAL BACKGROUND OF DURATION MODEL

The technique, which analyses the correlation of certain independent covariates with the survival or failure times, was primarily developed in the medical and biological sciences but it is also widely used in the social and economic sciences (Statsoft, 2006).

A common research question in medical and biological researches is to determine whether or not certain continuous (independent) variables are correlated with the survival or failure times. There are two major reasons why this research issue can not be addressed via straightforward multiple regression technique. First, the dependent variable of interest (survival or failure time) is most likely not normally distributed- a serious violation of an assumption for ordinary least squares multiple regressions. Second, there is a problem of censoring. Censored observations arise whenever the dependent variable of interest represents the time to a terminal event, and the duration of the study is limited in time (Ibid.).

To perform a basic duration analysis, we must define the survival function, choose a parametric distribution for duration, and choose covariates that may affect survival times (Kiefer, 1988).

2.1.3.1 THE HAZARD FUNCTION

Let us think of time to exit be a continuous random variable, T , and consider a large population of people who enter some given state at a time we shall identify as $T=0$. The calendar time of entry need not be the same for all people and in practical cases it usually will not be. Thus, T does not refer to calendar time but rather it measures time on person specific clocks that are each set to zero at the moment a person enters the state in question. T is the duration of stay in the state. The population is assumed to be homogenous with respect to the systematic factors, regressor variables, which affect the distribution of T . This means that everyone's duration of stay will be a realization of random variable from the same probability distribution (Lancaster, 1990).

We shall now define the probability that a person who has occupied a state for a time t leaves it in the short interval of length dt after t . The probability that such a person leaves the state within an interval dt at or after t is $P(t \leq T < t + dt \mid T \geq t)$ where the conditioning event that $T \geq t$ is just the event that the state is still occupied at t , that he has not left before then. If we divide this probability by dt we get the average probability of leaving per unit time period over a short time interval after t , and by considering this average over shorter and shorter intervals we define (Ibid.)

$$\lambda(t) = \lim_{dt \rightarrow 0} \frac{P(t \leq T < t + dt \mid T \geq t)}{dt}, \text{ as the hazard function.}$$

The hazard function is the instantaneous rate of leaving per unit time period at t . The rough interpretation of the function $\lambda(t)$ is that it is the probability of exit from a state in the short interval of length dt after t , conditional on the state still being occupied at t . We can express the hazard function in terms of the distribution and probability density functions of the continuous random variable T , the duration of occupancy. Let the distribution function be $P(T < t) = F(t)$, $t \geq 0$ at the point t , and let the probability density function be $f(t) = \frac{dF}{dt}$.

Then, by the law of conditional probability,

$$\begin{aligned}
 P(t \leq T < t + dt \mid T \geq t) &= \frac{P(t \leq T < t + dt, T \geq t)}{P(T \geq t)}, \\
 &= \frac{P(t \leq T < t + dt)}{P(T \geq t)}, \dots\dots (1a) \qquad \text{assuming } P(T \geq t) > 0, \text{ since the}
 \end{aligned}$$

intersection of the sets $t \leq T < t + dt$ and $T \geq t$ is just $t \leq T < t + dt$. In terms of the distribution function this probability equals

$$\frac{F(t + dt) - F(t)}{1 - F(t)}$$

Dividing by dt and letting dt go to zero, we get

$$\begin{aligned}
 \lambda(t) &= \lim_{dt \rightarrow 0} \frac{F(t + dt) - F(t)}{dt} * \frac{1}{1 - F(t)} \\
 &= F'(t) * \frac{1}{1 - F(t)} \\
 &= \frac{f(t)}{1 - F(t)} \dots\dots\dots (1b)
 \end{aligned}$$

Thus the hazard function at t is the probability density function divided by one minus the distribution function. One minus the distribution function occurs so often in mathematical expressions to do with durations and transitions that it has a special name, the survivor function, since it gives the probability of survival to t , or, in terms of relative frequencies, it gives the fraction of a large generation who stay at least t years. It also has a special notation, $1 - F(t) = S(t)$, and the more compact expression for the hazard is thus

$$\lambda(t) = \frac{f(t)}{S(t)} \dots\dots\dots (1c)$$

Since $f(t) = -dS(t)/dt$, equation() is a differential equation in t whose solution, subject to the initial condition $S(0) = 1$, is

$$S(t) = \exp\left\{-\int_0^t \lambda(u) du\right\} \dots\dots\dots (2), \text{ as can be verified by differentiation.}$$

Equation (2) describes how one can calculate the probability distribution of duration of state occupancy given the hazard function, and it is an important relation in the construction of models of transitions. Thus from equation (1c) and (2) the density function of T can be written

$$f(t) = \lambda(t) \exp\left\{-\int_0^t \lambda(u)du\right\} \dots\dots\dots (3).$$

Thus the hazard function, the density, the CDF and the survival function are all related (Green, 2003).

Survival times usually follow an exponential or weibull distribution though there are other sets of distributions like log-logistic and gombetz.

The *exponential* distribution is widely used as a model for duration data: The exponential is simple to work with and interpret, and is often an adequate model for durations that do not exhibit much variation(in much the same way that the linear regression model is simple and adequate if the data do not vary enough to reveal important non linearities) (Keifer,1988).

For the exponential distribution with parameter $\gamma > 0$,

$$F(t) = 1-\exp(-\gamma t)$$

$$S(t) = \exp(-\gamma t)$$

$$f(t) = \gamma \exp(-\gamma t)$$

$$\lambda(t) = \frac{f(t)}{S(t)} = \gamma$$

$$\Lambda(t) = \gamma t$$

The fact that the distribution depends only on one parameter, γ , is the drawback in application because the family of distributions obtained by varying γ is not very flexible.

The mean and variance of the exponential distribution $E(T)$ and $\text{Var}(T)$, is $\frac{1}{\gamma}$ so that the mean and variance can not be adjusted separately. Thus the exponential is unlikely to be an adequate description of the data if the sample contains both very long and short durations (Ibid.).

The *Weibull* distribution is a two parameter ($\gamma > 0$ and $\alpha > 0$) family with hazard function

$$\lambda(t) = \gamma \alpha t^{\alpha-1}$$

This is a simple generalization of the exponential distribution, which is obtained by setting $\alpha = 1$. The corresponding expressions for the distributions, survivor, density, and integrated hazard functions

$$F(t) = 1 - \exp(-\gamma t^\alpha)$$

$$S(t) = \exp(-\gamma t^\alpha)$$

$$f(t) = \gamma \alpha t^{\alpha-1} \exp(-\gamma t^\alpha)$$

$$\Lambda(t) = \gamma t^\alpha$$

In practice the parameter γ can depend on explanatory variables. The hazard function is increasing in duration if $\alpha > 1$, decreasing if $\alpha < 1$, and constant if $\alpha = 1$, which is exactly the exponential case. Duration dependence does not depend on the value of γ .

The distributions considered here and in most applied work are continuous. Continuous-time models seem appropriate for economic settings because there is typically no natural period in which economic decisions are taken (or economic surprises arrive). With a continuous time model, parameters are defined and can be interpreted independently of the period of the measure of data (Keifer, 1988).



2.1.3.2 ESTIMATION

NON-PARAMETRIC METHOD: *KAPLAN-MEIER/ PRODUCT-LIMIT ESTIATOR*

The Kaplan-Meier (1958) product-limit estimator is a strictly empirical, non parametric approach to survival and hazard function estimation (Green, 2003).

Suppose the sample survivor function for a sample of n observations with no censoring is

$\hat{S}(t)=n^{-1}(\text{number of sample points} \geq t)$ the empirical cumulative distribution function turned around. However, a modification is required to allow for censoring.

Let the completed durations in our sample of size n are ordered from smallest to largest, $t_1 < t_2 < \dots < t_k$. The number of completed durations k is less than n because some observations are censored (i.e., their spells¹ have not ended at the calendar time the study ends) and because of ties. Ties occur when two or more observations have the same duration.

Let h_j be the number of completed spells of duration t_j , for $j=1, \dots, k$. In the absence of ties the h_j are all equal to one

m_j be the number of observations censored between t_j and t_{j+1}

n_j be the number of spells neither completed nor censored before duration t_j . That is

$$n_j = \sum_{i=j}^k (m_i + h_i)$$

The hazard $\lambda(t_j)$ is the probability of completing a spell at duration t_j , conditional up on the spell's reaching duration t_j . A natural estimator for $\lambda(t_j)$ is

$$\hat{\lambda}(t_j) = h_j/n_j,$$

the number of 'failures' at duration t_j divided by the number 'at risk' at duration t_j . The estimator $\lambda(t_j)$ is not a 'rate' as such, as the width of the time window is undefined, and could be very different at different points in the chain of calculations. Because many intervals,

¹ Spell refers to number of consecutive periods in a state.

particularly those late in the observation period, might have zeros, the failure to acknowledge these intervals should impart an upward bias to the estimator (Green, 2003).

The corresponding estimator for the survivor function is

$\hat{S}(t_j) = \prod_{i=1}^j (n_i - h_i) / n_i = \prod_{i=1}^j (1 - \hat{\lambda}_i)$ which is the *Kaplan-Meier or Product Limit Estimator* (Keifer, 1988).

The Kaplan-Meier or Product Limit estimator helps us to plot graphs useful for displaying data on durations and for preliminary analyses, perhaps to suggest functional forms. It is also useful for specification analysis of more complicated models.

PARAMETRIC METHODS

Suppose that the family of duration distributions under consideration has been specified, so that the data distribution is known up to a vector of parameters ρ .

The density of duration of length t can be written as $f(t, \rho)$. If the sample of n completed spells were available and each individuals spell independent of the others, the likelihood function is

$$l(\rho) = \prod_{i=1}^n f(t_i, \rho).$$

In other words, the likelihood function is the joint probability distribution of the sample as a function of parameter ρ . When a spell is censored, at duration t_j for instance, the only information available is that the duration was at least t_j . As a result the contribution to likelihood from that observation is the value of the survivor function, $S(t_j, \rho)$, the probability that the duration is longer than t_k .

Let $d_k=1$ if the K^{th} spell is uncensored, $d_k=0$ if censored. Then the log-likelihood function $L(\rho) = \ln l(\rho)$ is

$$L(\rho) = \sum_{i=1}^n d_i \ln f(t_i, \rho) + \sum_{i=1}^n (1 - d_i) \ln S(t_i, \rho)$$

Which has completed spells contributing a density term $f(t_j, \rho)$ and censored spells contributing a probability $S(t_j, \rho)$.

The log-likelihood function can be written in terms of the hazard function

$$L(\rho) = \sum_{i=1}^n d_i \ln \lambda(t_i, \rho) - \sum_{i=1}^n \Lambda(t_i, \rho) \text{ since } f(t, \rho) = \lambda(t, \rho) S(t, \rho) \text{ and the fact that the log of}$$

the survivor function is minus the integrated hazard $\ln S(t, \rho) = -\Lambda(t, \rho)$. In practice it is customary to estimate the parameter by maximum likelihood (Ibd.).

SEMI-PARAMETRIC METHOD: *The Cox Proportional Hazards Model*

One limitation of the models given above is that external factors are not given a role in the survival distribution (Green, 2003). Nonetheless, explanatory variables can affect the distribution of durations in many ways. In ordinary regression models it is natural to assume, at least as a starting point, that explanatory variables affect the distribution of the dependent variable by moving its mean around (Keifer, 1988). There is no analogous clear-cut starting point for including explanatory variables in duration models. However, Cox(1972) proposed a semi-parametric model for the hazard function that allows the addition of explanatory variables, or covariates, but keeps the baseline hazard as an arbitrary, unspecified, nonnegative functional of time. The Cox hazard function for fixed-time covariates, $\mathbf{x}$, is

$$\lambda(t, \lambda_0, \beta, \mathbf{x}) = \lambda_0(t) \exp(\mathbf{x}' \beta) \dots\dots (a)$$

Where $\lambda_0(t)$ is a 'baseline' hazard defined as the hazard function for that individual with zero on all covariates (i.e., $\exp(\mathbf{x}' \beta) = 1$).

Because the baseline hazard is not assumed to be of a parametric form, Cox's model is referred to as a *semi-parametric model* for the hazard function. The survivor function corresponding to equation (a) is then

$$\begin{aligned}
 S(t;x) &= \exp\big[-\exp(x'\beta)\int_0^t\lambda_0(u)du\big] \\
 &= \exp\big[-\Lambda_0\exp(x'\beta)\big].....(b)
 \end{aligned}$$

Λ_0 in a squared bracket in (b) is called the baseline cumulative hazard function. Several methods are available for estimating the baseline cumulative hazard function (Klein and Moeschberger, 1997 cited in Thompson, Chhikara, and Conkin, 2003).

Cox's model has become the most used procedure for modeling the relationship of covariates to a survival or other censored outcome (Therneau and Grambsch, 2000 cited in Thompson et al, 2003). Its form is flexible enough to allow time –dependent covariates as well as frailty terms and stratification. However, it has some limitations. One of the limitations to using the Cox model with time fixed covariates is its proportional hazards assumption; that is, that the hazard ratio between two sets of covariates is constant over time. This is due to the common baseline hazard function canceling out in the ratio of the two hazards. Thus, for fixed-time covariates, the exponent of a coefficient describes the relative change in the baseline hazard due to that covariate.

The baseline hazard is typically considered a ‘nuisance parameter,’ and estimator of β is done by maximizing a profiled likelihood with $\lambda_0(t)$ being substituted for an expression involving β and x , as well as the times at which failures occurred(Klein and Moeschberger,1997 cited in Thompson et al, 2003).The likelihood with $\lambda_0(t)$ ‘profiled out’ is called the partial likelihood by Cox(1972).

For fixed-time covariates and independent observations, the partial likelihood is

$$L(\beta) = \prod_{i=1}^D \frac{\exp(x_i \beta)}{[\sum_{j \in R(t_i)} \exp(x_j' \beta)]^{d_i}} \dots\dots\dots(c)$$

Where D is the number of events, d_i is the number of events at time t_i, and R(t_i) is the risk set at time t_i (the number of subjects in the data set who have recorded failure times or censored times later than or equal to time t_i). The value of β that maximizes (c) is called the maximum partial likelihood estimate (MPLE).

ACCELERATED FAILURE TIME MODEL

Accelerated failure time model is also another method of analyzing the effect of explanatory variables on the hazard rate. In this model the effect of the regressor is to rescale time directly. If the baseline survivor function is S₀(t), then the survivor function for an individual with characteristics x is (Keifer, 1988)

$$S(t,x,\beta) = S_0[t \exp(x' \beta)]$$

In which time is essentially rescaled by multiplication exp (x' β). The hazard function associated with S is easily seen to be

$$\lambda(t,x,\beta) = \lambda_0[t \exp(x' \beta)] \exp(x' \beta)$$

Where λ₀ = -d ln S₀ / dt is the hazard function for the distribution S₀. The density is

$$f(t,x,\beta) = f[t \exp (x' \beta)] \exp (x' \beta).$$

Estimation of the accelerated failure time model proceeds by choosing functional forms for λ₀ and exp (x' β) and maximizing the resulting log-likelihood function.

We should note that the coefficients in both the proportional hazard model and the accelerated failure time model can be given partial derivative interpretations, analogous to that given to regression coefficients in the linear mode. However, assigning economic meanings to coefficients is a matter of modeling and judicious use of prior information (Keifer, 1988).

2.2. EMPIRICAL LITERATURE

The main importance of sorting out the linkages among the proxy factors which contribute to healthiness and the complementary nature of those factors would help in transform the unhealthy environment into a healthy one. Besides knowing the contribution of basic human necessities and their intricate relationship to health can be deemed as an indication for intervention areas that might improve the quality of life. For instance, improving the socio-economic condition, economic growth, increase in per capita health expenditure, the appropriate level of sanitation facilities and access for clean drinking water, appropriate level of nutrition would contribute to the wellbeing of children and society at large. Considerable attention has been paid in recent years to the influence of socio-economic status of parents, household environmental characteristics, and demographic factors on both the health and mortality of children.

Ali (2002) tried to examine the effects of water and sanitation on child's mortality risk in Egypt. The central question of the study was whether improvements in water and sanitation services were leading to a decrease in mortality of children under the age of five in Egypt. The data set used in the study originated from the DHS conducted in Egypt between November 1995 and January 1996. The analysis was conducted using a three part model: a probit model specification for the neonatal case, nonparametric, semi-parametric, and parametric duration model specifications are used for different age intervals including infant

and children less than five years. The findings of the study showed that access to municipal water and improved sanitation facilities had significant impact on child's mortality than other sources of water. Moreover, the study indicated mother education as an important factor to reduce child mortality. Based on the results she recommended that improving the society's knowledge about health care and hygiene is crucial to reduce risk of child's death.

Likewise, Woldemichael (1998) tried to look on the effects of household environment on child mortality in urban Eritrea, controlling other socio-economic factors. The data used for the study originated from the 1995 Eritrea Demographic and Health Survey that include environmental and socioeconomic variables. The data was analyzed by classifying the under five children into three age cohorts. For the neonatal period he used a logistic regression model while the Cox Proportional Hazard Model was used so as to address the censored observation. The study also assumed that in the surveyed area there is no major change in water or sanitation system. The study found that improvement in the provision of water supply and toilet facilities are likely to reduce mortality especially beyond the neonatal period.

Jacoby and Wang (2004) also examined the environmental determinants of child's mortality risk using a competing risks approach. In their study they evaluated alternative empirical methodologies for estimating the impact of environmental factors on child mortality in micro-data. Their primary question was whether taking in to account causes of death using a competing risk model than an all cause hazard model affects conclusions about the effectiveness of policy intervention. Using the 1992 China Health Survey (CHS), which was designed and implemented jointly by the China Statistical Bureau (CSB) and UNICEF, they estimated three models for the length of time that the child survives. The models are the

competing risk model(CRM) that allows for cause specific vector of coefficients, the piece wise weibull(PWW) which allows for age-specific coefficients), and weibull model(WM) which allows for duration dependence.

Looking at four hypothetical policies : (1) Universal Private access to safe water; (2) Universal access to basic sanitation facilities ; (3) Universal access to clean fuels; and(4) universal female primary education attainment, they found little difference in their impact across the three models. However, the largest and most significant impact comes from access to safe water. Increasing this dummy variable from its sample mean value of 0.33 to universal access would save more than 3 lives out of 1000 births, based on the CR and W models, and somewhat less than 3 lives according to the PWW model. And further they showed that policies that achieve universal female primary education attainment also have a significant impact on reducing under-five mortality (although only at the 10% level of significance for W and CR models).

Above all, their findings describe that comparison of results from the three different hazard models show no significant differences between the estimated environmental effects on child mortality from the CR model and those from simpler hazard models (using all-cause mortality) that do not explicitly account for cause of death. And hence, they concluded that the accuracy of overall policy conclusions about the effectiveness of environmental interventions would not be improved if one had access to cause of death information.

Jacoby and Wang (2004) also show in their analysis that interventions targeted at improving access to safe water in rural china have a statistically significant impact on reducing Under-5 mortality probability. Unlike the above studies, they found evidence suggesting that the impact of access to sanitation or clean cooking fuels on child mortality risk in rural china was insignificant.

The policy simulation also discloses that targeting environmental policies (in particular private access to safe water) in poor localities or poor households can avert more under-five deaths than untargeted interventions.

Most importantly, Jacoby and Wang (2004) emphasized that the potential analytical advantage of using the CR model rests on validating causal relationships using information on cause of death. In view of that, they came across that the probability of death from causes that should not be related to safe water, i.e., birth related deaths and neonatal tetanus, in fact are unrelated to access to safe water. Moreover, they uncovered that the probability of dying from diarrhea disease is the most responsive, at least in relative terms, to interventions that improve access to safe water.

Household's financial capacity to obtain appropriate health services and adopt healthy dietary and sanitary practices has an impact on child mortality. There are studies conducted to investigate the impacts of household income and consumption behavior on the likelihood of child's death. Lee et al (1997) examined the effects of improved nutrition, sanitation and water quality on child health in high mortality population. They paid particular attention on non-random allocation of household resources to children and to the selectivity effects of health interventions via their effects on child survival. Unlike the previous studies, they employed a simultaneous equation model with selectivity. They used semi-parametric estimation method so as to minimize the problem on the distributional assumption of the population of the disturbances. Lee et al (1997) used—the 1981-82 Nutrition Survey of Rural Bangladesh and the 1984-85 IFPRI Bukidnon, Philippines Survey. The data sets contained information regarding child health and survival, drinking water sources, sanitation facilities, a child specific nutritional intake.

In contrast to other studies, they concluded that variation in water sources and improvement insanitation facilities do not have significant impact on child mortality, but wealth and

parental schooling levels were significantly and positively associated with higher survival. The rationale behind such deviated result was that they focused on the reduced allocation of household income on children's health care with better facilities and not to survival selectivity.

There are many ways of measuring poverty. Of which the infant mortality rate is 'regarded as one of the most revealing measures of how well the society is meeting the needs of its people'. Ali (2001) made an attempt to investigate the interaction between child mortality and poverty in Pakistan. The analysis was relied on the Pakistan Socio-economic Survey conducted during April to July 1999. The study applied multiple classification analysis that requires dependent variable not to be badly skewed. The study found that mother's work participation, household crowding, unadjusted housing conditions and malnutrition have significant negative impact on the livelihood of a child, where maternal education showed a considerable reducing effect on child mortality. And further the study figured out heterogeneity among urban and rural dwellers. The study also mentioned that malnutrition had positive impact on mortality, but its effect is negligible in rural areas.

Wang (2002) described the existence of significant differences both in level and changes in child mortality between urban and rural areas. At the beginning of the 1990s, IMR and U5MR were 87 and 143 per 1000 births in rural areas whereas both figures are much lower in urban areas, being 67 and 105 per 1000 live births. However, despite the initial higher mortality in rural areas compared with that in urban areas, over the course of the 1990s, the rural population had experienced a much smaller reduction in child mortality. The annual rates of reduction in IMR are 1.7 per cent and 2.1 per cent, and in U5MR are 2.1 per cent and 2.6 per cent for rural and urban areas, respectively. According to Wang (2002) these two pieces of empirical evidences suggest that across low income countries health interventions implemented in the 1990s may not have been sufficiently effective at targeting the poor.

Low income status and hence lower health care utilization due to lack of finance and access to health care services could also be deemed as a prime factor for infant and child mortalities. Schellenberg et al. (2002) examined the risk factors for child mortality in Rural Tanzania. They conducted a community based Nested Case Control Study of Post-neonatal death in children less than five years. They investigated the effects of demographic, socio-economic, health seeking behavior and household environment on enhancing or impeding infant or child mortality. And they have shown that maternal education, socioeconomic status and breastfeeding have significant impact on infant and child mortality.

Poverty, disease, malnutrition and adverse reproductive and demographic characteristics keep on as impediments to bring improvements in infant and child mortality in many developing countries. Aguirre (1996) on his work entitled 'Child Mortality and Reproductive Patterns in Urban Bolivia' investigated the relationship between fertility and working patterns including demographic and socio-economic factors. The study was conducted using a Bio-demographic Hazard Model (which constitutes of three fitted Cox Proportional Hazard Models). The empirical findings of the study confirmed that pace of childbearing, breastfeeding, maternal age, birth order and use of contraceptives have important impact on infant mortality, even after controlling for maternal education. This entails that these reproductive pattern covariates have consistent effects even after the inclusion of education as a control.

Moreover, Zakir and Wunnava (1997) disclose that female literacy rates, per capita income, fertility rates, women's work status and government expenditures on health do have an impact on infant mortality rates. However, their empirical results suggested that fertility rates and female literacy rates have the strongest impact on infant mortality rates. But the former have negative significant impact on the livelihood of infants.

As it is a case for many underdeveloped countries, the Ethiopian economy remains highly dependent on the agricultural sector, which accounts for over 40 per cent of GDP and over 85 per cent of the population still depends on agriculture for their livelihood. This leaves a large part of the population at risk of famine due to low yields and vulnerability to frequent drought, a situation made worse by the weak rural infrastructure. The country's economy could not support itself and meet the prevailing societal demands. Lack of safe drinking water, ill-suited sanitation system, low utilization of health care services, the HIV/AIDS pandemic, narrow outreach of formal education and deep rooted poverty are the daunting challenges the country is faced with. The country experiences a higher rate of infant and maternal mortality compared with other Sub-Saharan African countries (MOH, 2004/5). Many studies (see Girma, 2001; Assefa et al, 2002; Markos and Eshetu, 2002; Assefa and Mekonnen, 1997) have also shown that socio-economic, demographic and health related factors are the root causes of higher infant mortality in Ethiopia.

Assefa and Mekonnen (1997) conducted a study in a small urban community of Ethiopia. They showed that higher birth order, early pregnancy and late pregnancy do have significant negative impact on the livelihood of infants. They used Cox's Proportional Hazard Model. Their findings show that maternal education, occupation of the father, household income, source of drinking water, availability of latrine, survival status of older offspring have direct effect on infant mortality.

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, breastfeeding and preceding birth interval.

CHAPTER THREE

3. DATA SOURCE AND MODEL SPECIFICATION

3.1. DATA SOURCE

The data set used in this study originates from the demographic and Health Survey (DHS) conducted in Ethiopia between February and May 2000. The Ethiopian DHS was implemented by the Central Statistical Authority (CSA) under the aegis of the Ministry of Health, Macro International Inc., provided the technical support through its MEASURE DHS⁺ Program. DHS is a large cross-sectional data set that is comparable across countries. It contains information obtained from ever married women aged 15-49 years regardless of whether they had any preschool children. Ethiopia DHS is nationally representative and hence it helps in a construction of wide range of basic population indicators (in addition to mortality rates). These indicators include basic household characteristics, fertility, household's access to services such as safe water and sanitation, utilization of basic health and education services, mother's education and knowledge of treatment of common child diseases. The Ethiopia DHS is the first survey of its kind in that country to provide national and regional states on population and health, estimates of a kind that are comparable to similar surveys conducted in other developing countries and permit making international comparisons

Ethiopia is a Federal Democratic Republic composed of 9 National Regional States (NRS): Tigray, Afar, Amhara, Oromia, Somalia, Beni-shangul-Gumuz, Southern Nations, Nationalities and Peoples Region (SNNRP), Gambella and Harari, and two Administrative States (Addis Ababa City Administration and Dire Dawa Council).

The 9 National Regional States in turn consist of around 580 Woredas which are the primary sampling units during the survey. The 2000 Ethiopia Demographic and Health Survey (DHS)

is a nationally representative survey covering 15,367 women aged 15-49 and 2,607 men aged 15-59.

In the survey extended information is only 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. Consequently the analysis focuses on 10873 children under the age of five. As a first step in the analysis of the effects of certain covariates on the survival time of a subject the data set is rearranged in to spell data. This then leaves us with 8576 children that are the center of attention in this study.

Then, children under five, which are the focus group of this study, are classified in to two age groups. Since the DHS Ethiopia is a monthly format the age classification is done accordingly. Hence the infant stage is defined to be post-neonatal (infant) between one month and 12 months of age and the childhood stage is defined to be between 12 and 60 months. However, this classification results in two problems. One, the classified data set may have censored observations, that is, not all live births have the chance to survive to the oldest age under investigation. Two, the behavior of mortality changes from one age to the next during the life span and complicates the analysis. In spite of these draw backs the use of hazard regression model permits inclusion of all live births and reflects the changing rates of mortality. Many researchers such as Woldemichael (1998), Ali (2002), and Ridder and Tunali (1999) have used this type of model.

3.2. ECONOMETRIC MODELLING

The methodology employed in this study involves a hazard model. A hazard model is multi-variate model which helps to analyze data set in which the dependent variable is the waiting time until the occurrence of a well-defined event (death, in our case), the subjects are censored, in a sense that for some units the event of interest has not occurred at the time the data are analyzed. Thus the model predicts the effects of covariates on the waiting time or survival of the subject.

Since the ultimate objective of this paper is to look on the effects of household environmental characteristics such as water and sanitation on the likelihood of the child’s mortality the multi-variate model of the child’s life duration is used.

Suppose that children are randomized and exposed to the situation with and with out economic, environmental, demographic and health related factors. Let $\lambda_{\alpha}(t)$ and $\lambda_0(t)$ be the hazard of death at time t for children who dwell in an environment with and with out the above-mentioned covariates, respectively. As this framework is simple and limited only on the two groups, it is reasonable to assume that $\lambda_{\alpha}(t)$ is proportional to $\lambda_0(t)$. That is, given two observations with different values for the independent variables the ratio of the hazard functions for those two observations does not depend on the time. Therefore, this proportional hazards model can be expressed in the form

$$\lambda_{\alpha}(t) = \mu \lambda_0(t) \dots\dots\dots (3.1)$$

For any non-negative values of t, where μ is a ratio of the hazards of death at any time for a child with and with out economic, demographic, environmental and health related constraints. So μ is known as the relative hazards ratio. If $\mu < 1$, the hazard of death at t is smaller for a child with the above constraints relative to a child with out the constraints. If $\mu > 1$, the contrary result will be obtained. Hence taking the above simplistic model as a spring board,

we can be able to draw a generalized model for n-observations. Let survival data contains a variables on n-children and denote the hazard function for the i^{th} of these by $\lambda_{\alpha}(t)$, $i=1,\dots,n$.

And further, as μ can not be negative, it is possible to express $\mu=\exp(\beta)$ where $\beta=\ln \mu$, and any value of β in the range $(-\infty,+\infty)$ will lead to a positive value of μ . However, $\beta>0$ if and only if $\mu>1$, and vice versa. This denotes that in the former case, the baseline hazard $\lambda_0(t)$ is greater than $\lambda_{\alpha}(t)$. Whereas, in the latter case $\lambda_0(t)$ is inferior to $\lambda_{\alpha}(t)$.

Suppose $X_1\dots X_m$ be explanatory variables. The set of these covariates are represented by the vector $X=(X_1,\dots X_m)'$

$\lambda_0(t)$ -is the baseline hazard function. It is the hazard for the respective individual when all independent variable values are equal to zero. That is, it is independent of the covariates. It is roughly analogues to the constant term in a standard regression, with the major exception that the baseline hazard denotes values that change overtime rather than a single value. It is assumed that the covariates have a multiplicative effect on the hazard. $\lambda_0(t)$ can take distribution like exponential, weibull, Gombetz and extreme value distribution or can be also a non-parametric function.

β - is a vector of regression parameters.

Then the proportional hazard function for an individual i , is defined as follows:

$$\lambda_i(t,x_i)=\lambda_0(t)*\mu(x_i) \qquad i=1,\dots, m \qquad \dots\dots\dots(3.3)$$

Where $\mu(x_i)$ is the hazard function at time t for an individual whose vector of explanatory variables are x_i , relative to the hazard for an individual for whom $x=0$.

Since, $\mu(x_i)$ is positive, it can be expressed $\exp(\theta_i)$ where θ_i is the linear combination of m explanatory variables. It is also called Risk Score. Therefore, $\theta_i=\beta_1x_{1i}+\dots +\beta_mx_{mi}$.

So that $\theta_i = \sum_{j=1}^m \beta_j x_{ji}$ where $i=1, \dots, m$. In the matrix notation, $\theta_i = \beta' x_{1i}$. Thus the proportional

hazard model defined in equation (3.3) can be rewritten as follows:

$$\lambda(t, x_i) = \lambda_0(t) * \exp(\beta' x_i) \quad , \text{ for } i=1, \dots, m \dots\dots\dots(3.3)$$

Hence, based on the proportional hazard function, Cox(1972) proposed the so called Cox Proportional Hazard Model, which is defined as follows:

$$\lambda(t, x_i) = \lambda_0(t) * \exp(\beta' x_i) \quad , \text{ for } i=1, \dots, m \dots\dots\dots(3.4)$$

Where i - refers to the number of individuals

$\lambda(t, x_i)$ - is a function of a baseline hazard $\lambda_0(t)$ and an exponential function of the covariate vector. It is the hazard function for failure time t for an individual i with covariate vector x_i .

t -is associated failure time

X_i - is a vector of covariates for individual i .

β - is a vector regression parameters of covariates. It indicates the relationship between the independent variable and the hazard of dying (the force of mortality). The effect of any covariate is to increase or decrease the hazard by a factor of proportionality.

$\lambda_0(t)$ - is an arbitrary and unspecified baseline hazard function.

$\exp(\beta' x_i)$ - is 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.

The Cox proportional hazard model is a semi-parametric model which has a very flexible method of estimation as the baseline hazard is estimated non-parametrically and eliminates the risk of corrupting the estimated parameters while the effect of the covariates takes a particular functional form. Moreover, Cox's model blends the merits of both life table and regression techniques. Unlike the traditional life-table analysis in which the conditional

probability of dying during a given age interval is assumed to be the same for all individuals, proportional hazards models allow for the possibility that the hazard rate of an event (death) may differ between individuals with different socio-economic or demographic characteristics. It is also important to make a note of that the point of verifying whether or not certain independent variables are correlated with survival failure times can not be addressed by other multiple regression techniques, mainly because of particular probability distribution assumption made on the dependent variable and the problem of censoring in the data (time to an event may not be complete). Hence Cox's Proportional Hazards Model is a suitable one for the type of study in question.

3.2.1. ESTIMATION OF THE REGRESSION COEFFICIENTS

To estimate the parameters of our model we use the Maximum Likelihood Estimation method since the proportional hazards model aspire to compare the odds-ratio.

Suppose that there are no ties between the event times, i.e., only one individual dies at each death time. From the sample of size n having d -distinct failures and $n-d$ censored survival times, let the observed ordered failure times be $t_1 < t_2 < \dots < t_d$. Then the likelihood function for β by taking the product of overall failure point t_j is

$$L(\beta) = \prod_{j=1}^d \frac{\exp(\beta' x_j)}{\sum_{k \in R(t_j)} \exp(\beta' x_k)} \quad j=1, \dots, d \tag{3.5}$$

Where d - is the number of distinct failure times

t_j - is the j^{th} ordered death time.

$R(t_j)$ - is the set of individuals who are at risk at t_j . It is the group of individuals who are alive and uncensored at a time just prior to t_j .

X_j - is the covariates for the individual who dies at the j^{th} ordered death time t_j .

And the summation in the denominator of the likelihood function is the sum of the values of values of $\exp(\beta'x_j)$ over all individuals who are at risk at time t_j . Individuals for whom the survival times are censored do not contribute to the numerator of the log likelihood function but they do enter into the summation over the risk sets at death times that occur before a censored time. Since it does not make direct use of the actual censored and uncensored survival times, the above likelihood function is a partial one and is known as Partial Likelihood Function.

For data that have n-observed survival times, denoted by $t_1, t_2, \dots, t_n$ and that η_i is an event indicator which is zero if the i^{th} survival time t_i is censored and unity otherwise. And hence the above partial likelihood function (3.6) becomes:

$$L(\beta) = \prod_{i=1}^n \left[\frac{\exp(\beta' x_i)}{\sum_{k \in R(t_i)} \exp(\beta' x_k)} \right]^{\eta_i} \dots\dots\dots (3.6)$$

The corresponding log likelihood function is given by:

$$\log L(\beta) = \sum_{i=1}^n \eta_i \left[\beta' x_i - \log \sum_{k \in R(t_i)} \exp(\beta' x_k) \right] \dots\dots\dots (3.7)$$

Therefore, the maximum partial likelihood estimate of β parameters in the proportional hazard model is obtained by maximizing the log partial likelihood function given in equation 3.7.

As mentioned at the outset of model construction, the relative risk for the reference category of each covariate is unity. Values greater than unity indicate that the relative risk of dying is greater for the group without the constraints compared with the reference group whereas values less than unity indicate a decrease in the risk.

The regression coefficients indicate the relative effect of the covariate on the hazard function and these coefficients vary around zero. A positive coefficient increases the value of the hazard function and therefore indicates a negative effect on survival time. A negative

coefficient decreases the value of the hazard function and therefore indicates a positive effect on survival time.

Therefore, in this study, a positive coefficient indicates a greater probability of hazards risk of infant mortality; and a negative coefficient indicates a smaller hazards risk of infant mortality. All the covariates intended for this survival analysis are time-constant independent variables. That is, they do not change in value over the spell time.

3.2.2. MODEL CHECKING

Despite its semi-parametric nature the Cox model is not different from an ordinary least squares model in that there are a number of diagnostics that will check whether a Cox model is well-fitting. These are Cox-Snell residuals, Martingale residuals, Deviance residuals, Schoenfeld residuals (scaled and un-scaled). But for this particular study the Cox-Snell residual is used in assign the general fit of the model.

The Cox-Snell Residuals

The Cox-Snell residual for the j^{th} observation is defined as

$$CS_{rj} = \hat{H}_0(t_j) \exp(x_j \hat{\beta}_x) \dots\dots\dots(3.8)$$

Where both $\hat{H}_0()$ and $\hat{\beta}_x$ are obtained from the Cox model fit. If the model fits the data well, the Cox-Snell residuals should have a standard exponential distribution with hazard function equal to one for all t , and thus cumulative hazard of the Cox-Snell residuals should be a straight 45° line. That is, the plot of the integrated hazard for generalized residuals should be a straight line with the slope equal to one.

Further, the model fit can be verified by estimating the empirical Nelson-Aalen Cumulative hazard function with the Cox-Snell residuals as the time variable along with the data's original censoring variable.

The Proportionality Assumption Test

The check for the validity of the proportionality assumption is made based on the analysis of Schoenfeld residuals. The basic idea in the wake of the proportionality assumption test based on the Schoenfeld residuals is to retrieve the residuals from Cox model, fit the smooth function of time to them, and then test whether there is a relationship. In its simplest form when there are no tied failure times, the Schoenfeld residual for covariate x_u , $u=1,..., p$ and observation j observed to fail is:

$$r_{uj} = x_{uj} - \frac{\sum_{i \in R_j} x_{ij} \exp\left(x_i \hat{\beta}_x\right)}{\sum_{i \in R_j} \exp(x_i \hat{\beta}_x)} \dots\dots\dots (3.9)$$

That is, r_{uj} is the difference between the covariate value for the failed observation and the weighted average of the covariate values (weighted according to the estimated relative hazard from a Cox model) over all those subjects that are at risk of failure when subject j failed.

Suppose that the coefficient on x_u does vary with time (in contrast of the proportional hazards assumption), so that β_u is actually

$$\beta_u(t) = \beta_u + q_i g(t) \dots\dots\dots (3.10)$$

Where q_i is some coefficient and $g(t)$ is some function of time. However, the proportional hazards assumption requires that $q_i=0$. Grambsch and Therneau (1994) provide a method of scaling the Schoenfeld residual to form

$$E(r_{uj}^* + \beta_u) = \beta_u(t) \dots\dots\dots (3.11)$$

Consequently, a graph of r_{uj}^* versus t_j provides an assessment of the proportional hazards assumption. The null hypothesis, therefore, is $H_0 : q_i = 0$, or the plotted curve has zero slopes. The rejection of the null hypothesis indicates a deviation from the proportional hazards assumption. This is equivalent to testing that the log hazard ratio function is constant over time (Cleves and Gould, 2004).

3.3. VARIABLE USED IN THE MODEL REGRESSION

The dependent variable used in this hazards model analysis is child's survival time, which is measured as the duration in months starting from the infant birth to death (if the event occurred) or from the infant birth to the survey date (censored data).

The independent variables in this study are classified into three groups: bio-demographic, socio-economic, and environmental variables.

3.3.1. ECONOMIC VARIABLES

In this category two variables are considered. These are mother's work status and wealth index of the household. Mother's work status is categorized as working and not working. The category not working is deemed as a reference group.

The variable wealth index is used as a proxy measure of the economic status of the household. In low income countries, where household income is often difficult to measure (especially in rural areas), consumption expenditures are often used in determining poverty. However, the DHS is very rich on asset ownership (that can be country specific) provides information on livestock and land ownership. Though asset ownership is less sensitive to short term fluctuations than consumption expenditures, asset ownership and consumption expenditures are strongly correlated. Thus wealth index is calculated by assigning a weight on factor score for each household asset and standardizing the resulting asset scores in relation to a standard normal distribution with a mean of zero and a standard deviation of one. And they are expressed in terms of quantiles (DHS/WB, 2002).

There are five categories for this variable i.e., first quantile, second quantile, middle quantile, fourth quantile and fifth quantile. The two extremes: the first and the fifth quantile indicate the lowest and highest economic status of the household, respectively. And the rest fall between these two extreme values. Since it is expected that child mortality is negatively

correlated with household wealthy index, a child from a household of higher economic status is anticipated to be at less risk of death.

3.3.2. BIO-DEMOGRAPHIC AND HEALTH RELATED VARIABLES

This group of variables consist sex of child, birth order, breastfeeding status, age of the mother at birth, education level of the mother and father, preceding birth interval, immunization, place of delivery, and marital status. Sex of the child is categorized as male and female. The category male is treated as reference group.

The child birth order is categorized as the first birth order, second to fourth birth and higher order births (birth order above 5). The birth order 2 to 4 is the reference category.

A good number of cases witness that first and higher order births run into higher mortality rates because the birth order reflects the components of the child’s biological endowments.

Likewise, the time interval between births preceding birth has an impact on the child’s risk of death. Thus it is expected that child mortality are inversely related with the length of the preceding birth interval.

The behavioral variable, breastfeeding is one of the most crucial variables considered in the study. Breastfeeding is the most appropriate food for young infants as it is nutritious, sterile, may reduce the ingestion of other often contaminated foods and confers immunity. In addition, it is believed that breastfeeding reduces the child’s exposure to pathogens (organism or substance that causes disease), breastfeeding, which indicates that a child is breastfed in his /her life span, is negatively related with a child’s risk of death.

The other variable is age of the mother at birth, which is categorized in to three age cohorts: “<20 years”, “20 to 34 years” and “above 35 years of age.” The age category “20 to 34 years”



is deemed as the reference, since patterns of mortality and age of the mother at birth often display typically U-shaped relationship. And further children born to both relatively young and old women have higher mortality rates than others. Nonetheless, the effect of maternal age at birth on infant mortality has to be biological. That is, it depends on reproductive maturity. A very young mother will have immature reproductive development and hence the child is more likely to be born before the appropriate delivery time or become underweight at birth. By the same token, weakness of reproductive tissue at old age is also a major problem even if the child raising practices are better than mothers who give birth at very young ages. Hence, children born to young and old mothers are at higher risk of death than children born to middle age mothers.

As a matter of fact, education has an impact on one's awareness and helps in keeping abreast of day to day information conveyed by health care providers. Consequently, education level of the child's mother is categorized as illiterate and literate. Since there are limited numbers of observations at the secondary level, the primary and secondary are grouped together. The literate category includes both complete primary/secondary and the incomplete primary/secondary. The category illiterate includes those who did not go to school and cannot read and write. Illiterate is treated as the base category. Since educated mothers have an access to clinical information on healthy bringing up of a child, care practices and prenatal treatment of a child better than illiterate mothers. Further more, they [Educated Mothers] are expected to demonstrate a better sanitary and hygiene practices and keeps the nutritional status of their children.

By and large, a child from educated family is anticipated to be at lower risk of death when compared with a child from uneducated family.

Place of delivery is also considered to indicate the place where the mother gave birth. It is categorized as home and health center. The category home is the reference category. For mothers' who gave birth at home, the child is expected to be at higher risk of death than a child born at health center.

The variable indicating the child's immunization status is also considered in the study. Immunization has a positive contribution to a child's survival as it is a way to grapple with the child's frailty to withstand disease. A child who is not immunized is at higher risk of death than immunized one. The variable is categorized as immunized and not immunized where the later is a reference category.

The other demographic variable considered in this study is marital status. It is categorized as separated and un-separated. The category separated is composed of single, divorced and widowed. While the category un-separated comprises married and living together. The separated category is treated as reference category. A child born to separated mother is expected to be at higher risk of death.

3.3.3. ENVIRONMENTAL VARIABLES

The environmental variables considered in this study are source of drinking water, sanitation facilities. As mentioned in the previous chapter, improved water supply and higher quality sanitation facilities are epidemiologically directly related to lower mortality. Thus the improvement of water supply is expected to be inversely related to risk of death. Because water's bacterial content is the one that affect health and since there is no available information about this variable and water purification practices, water supply as a source of drinking water will be considered as a proxy variable (see Ali, 2002).

Source of drinking water is classified in to covered/protected well water and surface water where the category surface water includes river, pond, and lake water.

The variable sanitation facility is categorized in to a pit-toilet, which considered being relatively better type of facility, and no- toilet facility, which consists of forests, bushes and other places where human waste is not contained to prevent it from contaminating the environment. The categories surface water, which comprises unimproved water supplies, and no-toilet facility that consist of unimproved sanitation facilities are treated as baselines in the analysis. However, due to lack of information on hygiene practices variables which help in analyzing hygiene practices such as '*wash hand after toilet*', '*wash hand before feeding the child*', '*whether cleansing agents used in the household like soap*' are not considered in this study.

CHAPTER FOUR

4. EMPIRICAL ANALYSIS

4.1. DESCRIPTIVE ANALYSIS

4.1.1. DESCRIPTIVE ANALYSIS OF INFANT MORTALITY

Infant mortality is defined to be the probability of dying within the first year of life. Of the total 8576 children considered in the study 1656 are found to be children at their infant stage. Out of the 1656 infants 51% are males and 49% are females. As indicated in Table 4.1 age of the mother at birth reveals that 61.53% of the mothers gave their first birth at the age of less than 20 years, 33.64% of the mothers gave their first birth at the age between 20-34 years, whereas the remaining 4.83% of the mothers gave birth at the age between 35-49 years.

Table 4.1 Descriptive Statistics of Demographic Variables, Infant Mortality

Variable	Category	Values	1≤Age≤12	
			Frequency	Percentage
Age of the mother at Birth	<20 Years	1	1019	61.53
	20-34 Years	2	557	33.64
	35-49Years	3	80	4.83
Sex of the Child	Female	0	812	49.00
	Male	1	844	51.00
Education Level of the mother	Illiterate	0	1436	86.70
	Literate	1	220	13.30
Education Level of the father	Illiterate	0	1110	67.10
	Literate	1	546	32.90
Marital Status	Un-separated	1	1571	94.87
	Separated	0	85	5.13

Moreover, Table 4.1 shows that 13.3% of mothers and 32.9% of fathers are literate. We also observe that 94.87% of the infants come from un-separated couples.

Concerning environmental variables 43.3% of infants sourced their drinking water from protected/covered well whereas the remaining get drinking water from surface water. Only 12.8% of infants belongs to households which have some type of sanitation facilities.

In low income countries like Ethiopia, where household income is often difficult to measure (especially in rural areas), a wealth index quantiles for each household are constructed. Accordingly, 38.58% and 9% of infants comes from families categorized under lowest quantile and highest quantiles, respectively. While the remaining 52.42% come from families categorized between the two extremes. The other economic variable considered in the study is the work status of the mother. As Table 4.3 shows below 44.38% of mothers are working (i.e. working outside home).

Table 4.2 Descriptive Statistics of Environmental Variables, Infant Mortality

Variable	Category	Values	1<Age≤12	
			Frequency	Percentage
Source of Drinking Water	Covered/Protected Well*	1	717	43.30
	Surface Water	0	939	56.70
Toilet Facility	Pit-toilet	1	212	12.80
	No Toilet Facility	0	1444	87.20

Table 4.3 Descriptive Statistics of Economic Variables, Infant Mortality

Variables	Category	Values	1<Age≤12	
			Frequency	Percentage
Wealth Index	Lowest Quantile	1	639	38.58
	Second Quantile	2	414	25.00
	Middle Quantile	3	272	16.42
	Fourth Quantile	4	182	11.00
	Highest Quantile	5	149	9.00
Work Status of the mother	Not Working	0	921	55.62
	Working	1	735	44.38

The other set of variables included in the study pertain largely to biological and health factors which are proximate to the survival of newly born babies. The data set for infants describe that above 97% of the infants are single born. Regarding the length of preceding birth interval Only 11.6% were born with the interval of greater than 24 months. The breast feeding status of the infants shows that 3.26% of the infants were never breastfed. The other variables reckoned with the survival of a child are place of delivery and immunization status of a child. Thus Table 4.4 discloses that 2.23% and 77.30% of the infants were delivered at the health center and immunized, respectively.

Table 4.4 Descriptive Statistics for Bio-Demographic and Health related Variables (Infant mortality).

Variable	Category	Values	1≤Age≤12	
			Frequency	Percentage
Birth Order	1	1	308	18.60
	2-4	2	673	40.64
	>4	3	675	40.76
Preceding Birth Interval 1	<24 months	1	1464	88.40
	Others	0	192	11.60
Child_twin	Single born	0	1612	97.34
	Twin	1	44	2.66
Breast Feeding	Not Breastfed	0	54	3.26
	Breastfed	1	1602	96.74
Immunization	Not Immunized	0	376	22.70
	Immunized	1	1280	77.30
Place of Delivery	Home	0	1619	97.77
	Health Center	1	37	2.23

4.1.2 DESCRIPTIVE ANALYSIS OF CHILD MORTALITY

Child mortality is defined to be the probability of dying with in exactly the first year and fifth year of life. Out of the total 8576 children considered in the study 6920 are children at their childhood stage. The sex ratio of the child mortality data shows that 51.1% are males and 48.9% are females. Table 4.5 discloses that 64.54%of the mothers are below 20 years during their first birth where as 0.14% of mothers are between 35-49 years of age. The remaining 35.32% of the mothers are between 20-34 years of age. The child mortality data set also indicated that more than 88% of the mothers and 72.56% of the fathers are illiterate. And further, Table 4.5 shows that only 7.2% of children come from separated families whereas the rest 92.8% come from un-separated families.

Table 4.5 Descriptive Statistics of Demographic Variables

Variable	Category	Values	12<Age≤59	
			Frequency	Percentage
Age of the mother at Birth	<20 Years	1	4466	64.54
	20-34 Years	2	2444	35.32
	35-49Years	3	10	0.14
Sex of the Child	Female	0	3384	48.90
	Male	1	3536	51.10
Education Level of the mother	Illiterate	0	6122	88.47
	Literate	1	798	11.53
Education Level of the father	Illiterate	0	5021	72.56
	Literate	1	1899	27.46
Marital Status	Un-separated	1	6421	92.79
	Separated	0	499	7.21

Regarding the environmental variables Table 4.6 reveal that children that come from households with access to covered/protected well water and surface water are nearly equal (i.e. 50.77% and 49.23%, respectively). The variable toilet facility, a surrogate to sanitation facilities, shows that more than 80% of children come from households without toilet facility.

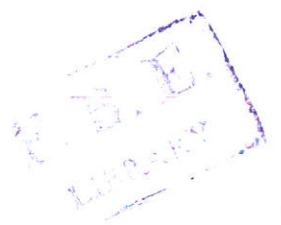


Table 4.6 Descriptive Statistics of Environmental Variables

Variable	Category	Values	12<Age≤59	
			Frequency	Percentage
Source of Drinking Water	Covered/Protected Well*	1	3513	50.77
	Surface Water	0	3407	49.23
Toilet Facility	Pit-toilet	1	1212	17.50
	No Toilet Facility	0	5708	82.50

Table 4.7 pertains to the descriptive statistics of economic variables. It explains that above 36% of children come from the lowest quantile while only 12% come from the highest quantile. The percentage distribution of the other economic variable-work status of the mother- indicates that 59.23% of mothers were working while the rest 40.77% are not working (i.e. they are not working outside home).

Table 4.7 Descriptive Statistics of Economic Variables

Variables	Category	Values	12<Age≤59	
			Frequency	Percentage
Wealth Index	Lowest Quantile	1	2491	36
	Second Quantile	2	1730	25
	Middle Quantile	3	1107	16
	Fourth Quantile	4	761	11
	Highest Quantile	5	830	12
Work Status of the mother	Not Working	0	2821	40.77
	Working	1	4099	59.23

Table 4.8 elaborates the bio-demographic and health related variables. The percentage distribution of the order with which a child was born-Birth Order- show that only 18.12% of the children were first born. While 41.3% and 40.58% were born with the birth order between 2nd -4th and higher order births, respectively.

The preceding birth interval shows that 81.55% of children were born with less than 24 months interval while the remaining 18.45% were born with above 24 months interval. The variable breastfeeding implied that more than 96% of children were breastfed.

Immunization status of a child and the place where the child was delivered are important variables in determining the survival status of a child. Thus Table 4.7 reveals that 78.25% of children were immunized and only 2.72% were delivered in health centers.

Table 4.8 Descriptive Statistics for Bio-demographic and Health related Variables

Variable	Category	Values	12<Age≤59	
			Frequency	Percentage
Birth Order	1	1	1254	18.12
	2-4	2	2858	41.30
	>4	3	2808	40.58
Child twin	Single born	0	6785	98.05
	Twins	1	135	1.95
Preceding Birth Interval 1	<24 months	1	5643	81.55
	Others	0	1277	18.45
Breast Feeding	Not Breastfed	0	252	3.64
	Breastfed	1	6668	96.36
Immunization	Not Immunized	0	1505	21.75
	Immunized	1	5415	78.25
Place of Delivery	Home	0	6732	97.28
	Health Center	1	188	2.72

4.2. Empirical Analysis

4.2.1. Econometric Analysis

The estimated model is the Cox Proportional Hazards model given in 3.6, that is:

$$\lambda(t, x_i) = \lambda_0(t) * \exp(\beta' x_i) \quad \text{Where } i=1, \dots, m$$

The variables considered in the model (x_i) includes birth order, mothers age at birth, mothers education, fathers education, source of drinking water, toilet facility, preceding birth interval, place of delivery, immunization, breastfeeding, wealth index quantiles, and marital status.

A Multicollinearity test has been made to check whether there is any strong relationship or interdependency among the above-mentioned explanatory variables. That is, it becomes difficult to sort out individual effects of variables used in the regression if multicollinearity exists. As shown in Annexes 1 and 2, the maximum values of the correlation coefficient among the explanatory variables are 0.66 and 0.65 for the infant mortality and child mortality data, respectively. Thus we can conclude that multicollinearity is not a problem in our model.

The specification check has been made for all the variables included in the model using the martingale residuals generated while fitting the Cox regression model. That is, suppose M_i is the martingale residual of the i^{th} observation obtained when no covariates included in the model. Assume a true relative hazard of a form $\lambda(t \mid x_i) = \lambda_0(t) \exp\{f(x_i)\}$ where x_i is the covariate vector for the i^{th} subject and $f(\cdot)$ is some function in our case $\beta'X$. It may be shown that M_i is approximately $k(\beta'X)$, where k is a constant that depends on the number of censored observations. Thus this implies that there is a linear relationship between $\beta'X$ and M_i . While used with a single predictor x a smooth plot of martingale residuals versus x may provide a visual indication of the transformation needed to obtain a proper functional form for x . However, the results obtained show that the variables in the model have no specification problem while fitting

the Cox model. This is confirmed observing the scatter plots of the martingale residuals against the covariates. And hence the smoothed curve in the plot yields approximately linear smooth and leads us to believe that the covariate's functional form is better to be included in the model.

4.2.1.1 Test for Proportionality Assumption After Fitting Cox Model

To check whether the Cox model fit is valid, we must check the proportionality assumption. That is, we must check whether the effects of covariates on risk remain constant over time. We illustrated the Schoenfeld (1982) residuals. The scaled Schoenfeld residuals, which help to perform a variable-by-variable test, have been fitted to Cox model. The test statistics of scaled Schoenfeld residuals given in Table 4.8 assesses whether the null hypothesis defined in section (3.2.2) is valid. In view of that the PH test for all variables in infant mortality model shows that the chi-square value of each variable and the overall chi-square are less than the table value of chi-square, and hence the test provides no evidence against the Proportional Hazards assumption. Moreover, the graph of scaled Schoenfeld residuals against time have a zero slope confirming that the rejection of the null hypothesis (see Annex 3-30).

Table 4.9 Test of Proportional Hazards Assumption, Infant Mortality

Variables	rho	χ^2	df	Significance
Sourced_wat	0.02859	0.14	1	0.7129
Toilet_fac	-0.00085	0.00	1	0.9916
Mother_educ	0.10173	0.45	1	0.2291
Father_educ	-0.08374	0.13	1	0.2877
Woman_working	0.12355	0.42	1	0.1196
Child_twin	-0.00160	0.00	1	0.9840
Sex_child	-0.03582	0.19	1	0.6595
Breastfeeding	0.03811	0.37	1	0.5410
Marital_stat	-0.03289	0.17	1	0.6785
Prec_birthinginterval1	0.06350	0.73	1	0.3924
Place_deliv	0.01455	0.03	1	0.8571
Immunization	0.08157	1.04	1	0.3073
Second Quantile	0.01117	0.02	1	0.8933
Middle Quantile	0.02295	0.08	1	0.7739
Fourth Quantile	0.02160	0.07	1	0.7931
Highest Quantile	-0.02690	0.12	1	0.7338
Agemother_1stbirth1	0.11578	2.01	1	0.1560
Agemother_1stbirth2	0.02301	0.03	1	0.9870
Birth_order1	-0.00588	0.01	1	0.9391
Birth_order2	-0.00492	0.00	1	0.9506
Global test		7.45	20	0.9653

Table 4.10 Test of Proportional Hazard Assumption , Child Mortality

Variables	rho	χ^2	df	Significance
Sourced_wat	0.05262	0.09	1	0.1074
Toilet_fac	-0.01101	0.11	1	0.7352
Mother_educ	-0.00637	0.04	1	0.8433
Father_educ	-0.04888	0.38	1	0.8233
Woman_work~g	0.03169	0.92	1	0.3369
Child_twin	-0.12847	16.90	1	0.0000
Sex_child	0.05215	0.41	1	0.7130
Breastfeed~g	-0.00212	0.00	1	0.9491
Marital_stat	-0.01430	0.19	1	0.6620
Prec_birth~1	0.04134	1.60	1	0.2060
Place_deliv	0.02210	0.45	1	0.5004
Immunization	-0.01105	0.11	1	0.7377
Second Quantile	0.00939	0.08	1	0.7763
Middle Quantile	0.00801	0.06	1	0.8073
Fourth Quantile	0.00551	0.03	1	0.8664
Highest Quantile	0.02987	0.83	1	0.3627
Agemother_~1	-0.00717	0.05	1	0.8265
Agemother_~2	0.02189	0.44	1	0.5087
Birth_order1	0.00382	0.01	1	0.9072
Birth_order2	0.00555	0.03	1	0.8659
Global test		6.91	20	0.9345

However, the proportional assumption test for the child mortality model revealed that the variable used to capture whether a child is part of a twin (child_twin) has a χ^2 value greater than the critical value at 1 degrees of freedom and hence we reject the null hypothesis that the effects of the variable child_twin does not vary overtime.

4.2.1.2 Global Goodness-of-Fit Test Using Cox-Snell Residuals

A formal test of overall goodness-of-fit of Cox model is carried out for the two age groups using the Cox-Snell residuals. A plot of Cox-Snell residuals shown below substantiated the requirement for a well-fitting Cox model. That is, the graph of the Cox-Snell residuals should have a standard exponential distribution with hazard function equal to one for all, and hence the cumulative hazard of the Cox-Snell residuals should be a straight 45° line. And further we estimated the Nelson-Aalen cumulative hazard function, with the Cox-Snell residuals as the time variable along with the data's original censoring variable. The graphs given below show that the plotting of Nelson-Aalen cumulative hazard estimator for the Cox-Snell residuals has fit well the reference line, though some variability is observed particularly in the right hand side. This variability is the consequence of the reduced effective sample caused by prior failures and censoring.

Figure 4.1 Cumulative Hazards of Cox-Snell Residuals, Infant Mortality Model

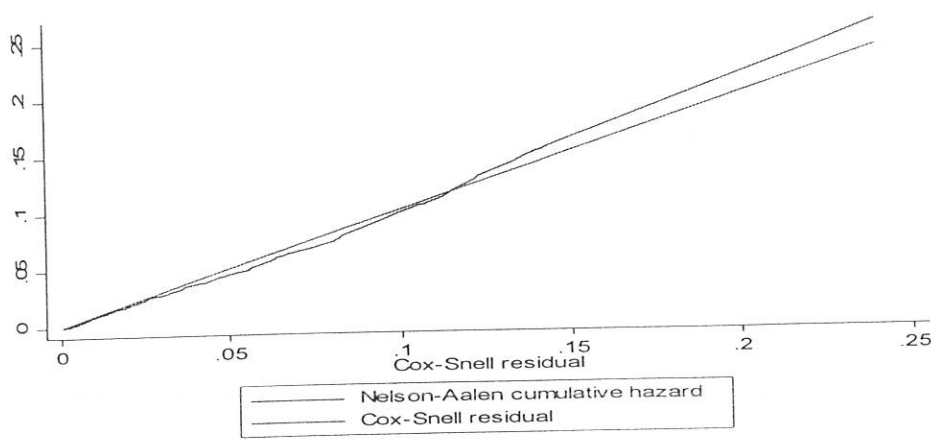
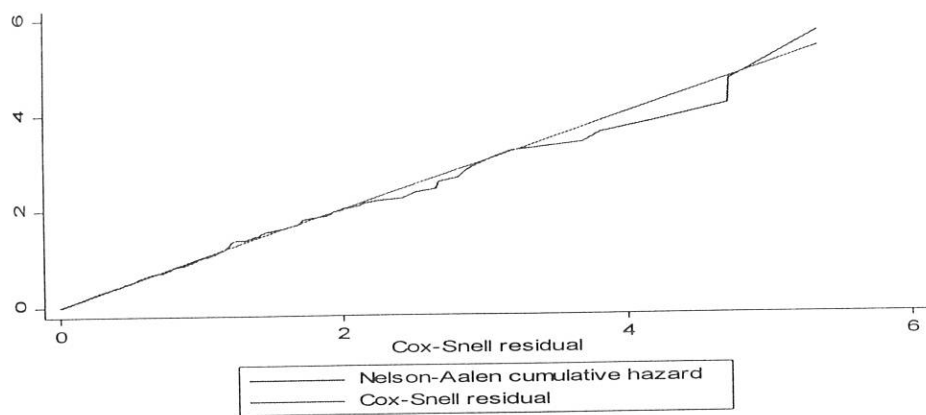


Figure 4.2 Cumulative Hazards of Cox-Snell Residuals, Child Mortality Model



4.2.1.3 Estimated Results and Discussion for Infant Mortality²

Consistent with expectations and other studies (Ali, 2002; Klaauw and Wang, 2005; Jacoby and Wang, 2004; Hiwot, 2004) the Cox regression results predicting infant mortality Table 4.9 show that maternal education play a key role in the determination of post neonatal mortality through out rural Ethiopia.

Educated mothers are more likely to use the health service, feed their children better, use contraceptives and act in various ways to improve on traditional means of health care. The key issue is not the increased social standing of the educated women but the changes in their behavior and attitudes (Caldwell, 1979 and 1987). The results in Table 4.9 confirm the hypothesis that the higher the education of mother, the lower the infant and child mortality. Thus evidence of an inverse relationship between level of education achieved by mother and the mortality experience of the child is observed. The result in Table 4.9 shows that children born to educated mothers face 1.42% of the mortality risk faced by children born to un-educated mothers.

² The estimation results for Wealth Index Quantiles showed a non-sensible and insignificant result and left out from the infant mortality model.

An infant from educated father is 3.18 % lower riskier than an infant from un-educated father. The probable reason for such inverse relationship between infant mortality and fathers' education is that educated fathers may have awareness on healthy nurturing of infants and have higher demand for health services and sanitary practices.

The model for infant mortality also includes covariates of immunization, birth order, place of delivery, and mother's age at birth to see their impact on infants' survival.

Infants whose mothers' age is less than 20 years are 1.54 times more likely to die than the reference category (20-34years). While children whose mothers' aged 35 and above have 1.31 times more likely to die than the reference category. Again it is consistent with the literature that children born to very young mothers are associated with high mortality risk because of the physiological immaturity combined with the social and psychological stress that comes with it. The high risk at older ages is due to maternal depletion associated with pregnancy complications and repeated child births.

Children who are breastfed face a risk of death 3.71 times higher than those who are not breastfed. The reason for such counter intuitive result may be untimely introduction of supplementary foods matched with the poor hygienic practice of the rural communities in Ethiopia diminishes infants' probability of survival.

Table 4.9 reveals that the variable indicating the first born baby (first birth order) has a negative impact on the chance of survival of the infant. In other words, the first born babies in rural area of Ethiopia are 20.20% higher riskier to death than babies born with in the range of 2nd and 4th birth order (the reference category). Similarly, infants who are at birth order above 5 (higher birth order) have a higher chance of death than the reference category. The risk of death for an infant at higher birth order is 85.57% higher than the reference category. Thus both variables indicating first birth order and higher birth order have shown a detrimental effect on infants' survival.

Marital status plays a vital role in reducing infant's mortality. An infant from un-separated family is 30.3% less likely to die than an infant whose parents are separated. An infant raised by both parents seem to have a better chance for survival since at least one of the parents in un-separated family care for the child's survival and well being.

The relative risk of death of an infant from a household having access to covered/protected well water is 28.84% less than those having access to surface water. The significance of source of water is consistent with a study by (Jacoby and Wang, 2004).

The risk of death of an infant from a household having access to some type of sanitation facilities (Pit-toilet) is 54.74% higher than those who do not have access to sanitation facilities.

The probable reason for such a positive relation ship between toilet facilities and risk of death is that the availability of sanitation facilities with poor hygiene practice can not be a guarantee to bring reduction in infant mortality. Thus the result shows that hygiene practice like *washing hand after toilet* may have a larger impact on minimizing infant mortality. The result is consistent with Ali (2002). Further, this finding is espoused by the results of Lavy et al. (1996) who showed that access to poor water and sanitation in the urban Ghana decreases the risk of mortality.

The risk of dying for a child born with a preceding birth interval < 24 months is 46.37 % higher than a child born with an interval above 24 months. This is consistent with the studies by (Klaauw and Wang, 2005) who have found a significant effect on the length of preceding birth interval on infant mortality. Whitworth and Stephenson (2002) suggest that after a short birth interval there is a more intense pressure on the work load of the mother and the household's resource, which increase mortality rate.

The place where children were delivered has shown that children delivered at health centers have faced risk of death of 24% of the risk faced by those who were delivered at home. This shows

that births delivered at home (attended by the traditional/relatives/ neighbor birth attendants (midwives)) have faced a higher risk of mortality than births attended by physicians and paramedics. Children given immunization have a lower risk of death of 0.94 times of the reference category (No immunization).

Table 4.11: Results from Cox Proportional Hazards Model for the Effects of environmental, bio-demographic, and economic variables on infant mortality in rural Ethiopia, 2000 ETDHS

Variables	Coefficients	Std Err.	Wald test	Significance	Exp (Coeff.)
Sourced_wat	-0.34	0.13	-1.79	0.073***	0.7116
Toilet_fac	0.44	0.41	1.65	0.099***	1.5474
Mother_educ	-0.01	0.24	-2.06	0.002*	0.9858
Father_educ	-0.03	0.19	-3.16	0.071***	0.9682
Woman_work~g	0.00	0.17	0.02	0.985	1.0032
Child_twin	-0.46	0.20	-2.46	0.104***	0.6332
Sex_child	-0.45	0.11	-2.61	0.009*	0.6358
Prec_birth~1	0.38	0.38	2.48	0.038**	1.4637
Breastfeeding	1.31	1.47	3.30	0.001*	3.7085
Marital_stat	-0.36	0.20	-4.26	0.007*	0.6997
Birth_order1	0.02	0.23	-3.07	0.042**	1.0202
Birth_order2	0.62	0.41	2.79	0.005*	1.8551
Agemother1	0.43	0.12	-2.32	0.021*	1.5373
Agemother2	0.27	0.38	-2.54	0.088***	1.3100
Place_deliv	-0.27	0.35	-1.95	0.053***	0.7599
Immunization	-0.06	0.20	-2.31	0.054***	0.9418

Model Statistics

-2Log-likelihood	1447.30
Model χ^2	59.06
Degrees of Freedom	16
Significance	0.010
N	1656

* Significant at 1%

** Significant at 5%

***Significant at 10%

4.2.1.4 Estimation Results and Discussion for Child Mortality

The model of child mortality includes the covariates such as sex of child, mother's age at birth, education of mothers, education of fathers, source of drinking water, toilet facility, birth order, place of delivery, immunization, breastfeeding, wealth index of a household represented by four dummy variables of wealth index quantiles and marital status to see their impact on child's survival.

The estimation result presented in Table 4.10 shows that maternal education has demonstrated a significant counter intuitive result. Children born to literate mothers have a higher risk of death 1.03 times than the reference category (illiterate). This may be due to two reasons: first, though child's mother is educated lack of access to safe drinking water, sanitary facilities and health services and the walking distance to get services located in a far distance may preclude mothers consistently care for and take their children to health centers while they are sick. Second, even if the service is available the user fee of health services which is unaffordable to rural poor mothers prevents them from getting health service in their proximity.

Father's education is significantly associated with reduced risk of child mortality. It has been found that children born to educated fathers have 0.97 times less likelihood of death than children born to uneducated fathers (reference category).

The result for child mortality also showed that birth order has a detrimental effect on the likelihood of child's survival. In view of that, first born children experienced a risk of death 1.3 times higher than birth order between 2nd and 4th, which is the reference category. And further, children born in the higher birth order (above 4th) face 1.52 times higher risk of death than the reference category. This high mortality risks of first and higher order births may be related to the

age of the mother at the child's birth which revealed the possibility of increase in risk of mortality at younger and old ages.

Breastfed children were 1.3293 times more likely to die than those who were not breastfed. The probable reason for such contradictory result is that in most rural communities of Ethiopia breastfeeding is punctuated with an early introduction of supplementary foods. Thus the poor sanitary conditions and quality of the foods given to a breastfed child may therefore diminish the child's survival chances. Knodel (1977) indicated that the impact of breastfeeding on infant and child mortality, in most cases, depends on the nutritional quality of substitute foods, the sanitary conditions surrounding artificial feeding, and the overall health conditions of the infants' environment.

Children given immunization face only 0.08% of the risk of death faced by children who were not immunized (the reference category). Thus this result implies that immunization has a significant impact on determining the survival status of children and lowers the risk of death substantially.

Maternal age at birth is an important variable in rural Ethiopia where child bearing begins at an early age. The literature shows that the relationship between child mortality and maternal age has been found to be non-linear and U-shaped- the risk being highest at both the lower and upper ends. This variable is a proxy for the mother's physiological, mental and emotional maturity; it also measures the mother's experience with child care. The results found show consistency with this theory and the children whose mother's age is less than 20 years and above 34 years increase the risk of death by 14.35% and 6.18% while compared with the reference category (20-34 years). However, the risk of death is relatively low for children born to old age mothers reflecting the better experience they may have in child care and rearing practice.

The difference in child mortality by the sex of child shows that boys are 0.98 times less likely to die than girls. This implies that the sex differentials in child mortality may be the out come of the deliberate behavior of parents, the cultural norms and strong and deep-rooted preference for sons.

The findings regarding environmental variables show that children who dwell in households with access to covered/protected well water (i.e., safe water) reduces child mortality by 1.42%.

Children who had access to some type of sanitation facilities (pit-toilet) were 1.14 times more likely to die than the reference category (no toilet facility). This contradictory result to our expectations or intuition indicates that access to toilet facility increases risk of child's mortality.

This may be due to low hygienic awareness matched with drilling a pit-toilet in close proximity to dwelling to make them convenient for visits during night time.

Regarding place of delivery children who were delivered in health centers had 0.99 time lower risk of death than children who were delivered at home (reference category). Since health centers are expected to provide healthcare and have environmental sanitation at the time of delivery, children delivered in health centers had less chance of death.

The result given in Table 4.10 shows that longer preceding birth intervals are significantly associated with reduced risk of child mortality. Children born with preceding birth interval of less than 24 months face risk of dying 1.23 times higher than children born with preceding birth interval of < 24 months.

The results for the wealth index quantiles imply that the effect of household wealth status is insignificant. But we have something to talk about. The signs of wealth index quantiles conform with our expectation showing that the household's wealth status and child mortality has an inverse relationship.

Table 4.12: Results from Cox Proportional Hazards model for the Effects of environmental, demographic, and economic variables on Child mortality in rural Ethiopia, 2000 ETDHS

Variables	Coeff.	Std. Err.	Wald test	Signif.	Exp (Coeff.)
Sourced_wat	-0.01	0.07	-0.21	0.0320**	0.9858
Toilet_fac	0.13	0.08	1.78	0.0750***	1.1442
Mother_educ	0.03	0.09	2.35	0.0240*	1.0324
Father_educ	-0.03	0.08	-1.94	0.0900***	0.9682
Woman_work~g	0.03	0.07	0.46	0.6440	1.0321
Sex_child	-0.02	0.07	-2.29	0.0040*	0.9810
Breastfeed~g	0.28	0.11	2.70	0.0070*	1.3293
Marital_stat	-0.09	0.11	-1.78	0.0340**	0.9139
Prec_birth~1	0.12	0.08	-1.77	0.1010***	1.1274
Place_deliv	-0.35	0.25	-4.37	0.0020*	0.7077
Immunization	-0.01	0.08	-2.10	0.0210*	0.9920
Second Quantile	-0.06	0.12	-0.52	0.6050	0.9402
Middle Quantile	-0.02	0.11	-0.22	0.8230	0.9756
Fourth Quantile	-0.03	0.11	-0.24	0.8110	0.9732
Highest Quantile	-0.15	0.12	-1.28	0.2020	0.8565
Agemother_~1	0.06	0.07	-1.91	0.0600***	1.0618
Agemother_~2	0.46	1.00	-1.86	0.0440**	1.5840
Birth_order1	0.27	0.09	2.80	0.0050*	1.3035
Birth_order2	0.42	0.08	5.41	0.0000	1.5215

<i>Model Statistics</i>	
-2Log-likelihood	13071.898
Model χ^2	46.42
df	20
Significance	0.00
N	6920

*Significant at 1% **Significant at 5% ***Significant at 10%

In general, the findings revealed that socio-economic, environmental and demographic variables are more important determinants of child's survival. Moreover, the two Cox regression results showed that the effects of socio-economic, demographic and environmental variables on infant and child mortality are different. Hence, the interventions needed to reduce the mortality risk of children also differ based on their age category or stage of infancy. The following chapter presents the concluding remarks and policy implications of the study

CHAPTER FIVE

5. Conclusion and Policy Implications

5.1. Conclusion

In this study an attempt is made to show the effects of demographic, economic and environmental variables on child's mortality in rural Ethiopia. However, the study conducted emphasized on describing the effects of water and sanitation on child's survival. The data used in the study is obtained from the 2000 Ethiopian DHS conducted between February and May 2000. It was implemented by the Central Statistical Authority (CSA) under the auspices of the Ministry of Health, Macro International Inc., provided the technical support through its MEASURE DHS+ Program. It contains information obtained from ever married women aged 15-49 years regardless of whether they had any preschool children. The women's, men's and household questionnaires, that help in extracting information on household characteristics, fertility, family planning awareness and use of contraceptive methods, infant and child mortality, maternal and child health and knowledge of HIV/AIDS, educational background of household members and their wealth status, were administered during the survey. The survey was nationally representative and hence it helps in a construction of wide range of basic population indicators. These indicators include basic household characteristics, fertility, household's access to services such as safe water and sanitation, utilization of basic health and education services, mother's education and knowledge of treatment of common child diseases.

A two part Cox proportional Hazards model was estimated in which the parameters were estimated by the regular maximum likelihood method: one for the infant and the other for child mortality. The findings of the study illuminated that environmental factors such as water and

sanitation, child's birth order, age of the mother, educational background of child's parents, length of preceding birth interval and sex of a child have significant impact on the probability of both infant and child survival.

Though there are various environmental determinants of child's mortality, the study used only two variables (source of water and toilet facility) as explanatory variables for environmental determinants.

The study showed that source of water has a significant effect on both infant and child mortality. An infant or a child that come from a household with access to covered/ protected well water has lower risk of death than a child/an infant that belongs to a household which consume water from surface water (i.e., unsafe source of water). This implies that surface water could make infants/ children susceptible to health hazards. The advantage of having access to covered/protected well water prevails in the infant case with 28.84% reduction in mortality risk. In the same manner with an application to Eritrea, Woldemichael (1998) shows that the effects of household environment (water supply and toilet facility) is large and statistically significant during the post-neonatal and childhood periods.

The result for the availability of sanitation facility has shown a counter intuitive but sensible outcome. That is, the result shows a statistically significant positive relationship between availability of sanitation facilities and mortality. The probable reason for such differing outcome may relate to the inappropriate use of sanitation facilities matched with the poor hygiene practice of the rural poor households could worsen the health problems associated with household environment. Thus it is shown that children who come from households with toilet facility have a higher risk of death than their counterparts. This outcome is conforms to Lavy et. al. (1996) who shows that access to poor water and sanitation in the urban Ghana decreases the risk of mortality.

Likewise, breastfeeding too demonstrated a contradictory result to a priori expectation. That is, breastfeeding and mortality found to be positively related and statistically significant in both infant and child cases. The justification for such contrast pertains to factors that may reduce the advantages of breastfeeding over supplementary feeding. Since breastfeeding in most of rural communities in Ethiopia is interspersed by the early introduction of supplementary foods, the issue of supplementary feeding has paramount importance. The poor sanitary conditions and quality of the foods given to a breastfed infant/child may therefore diminish the child's survival chances.

Infants and children of first and higher order births experience higher risk of dying. The plausible reason for the positive correlation of first birth to risk of death may relate to age of the mother at birth and knowledge of childcare practices. The reproductive and psychological maturity of mothers' during their first birth is believed to affect the survival chances of a child. In view of this reason, in a society where early marriage is rife, it is very likely that first born children could not get proper treatments for their mothers' would have less knowledge in childcare practices. However, the risk of death of higher order births is relatively less when compared with first order births. This may be due mainly to the experience and knowledge in child care practice that mothers' accumulate during their preceding births.

And further maternal education is found to be important to reduce both infant and child mortality. Infants/ children born to literate mothers have less probability to face risk of death. The important conclusion from this finding is that educated mothers may have good sanitary and dietary practices that enhance child's prospects of survival. Moreover, educated mothers are more likely to use the health service, use contraceptives and act in various ways to improve on traditional means of health care.



The results for infant/ child mortality by the sex show that girls have higher chance of facing risk of death than boys. Therefore, this differences show that there is gender discrimination in child care and feeding practice of the communities in rural Ethiopia.

5.2. Policy Implications

According to Todaro (2000) the principal goals of development are improving the welfare of the people experiencing the greatest hardship, broadly recognized to be women and children. Thus in developing countries like Ethiopia where we observe high incidence of poverty, the future reduction in it could come through a sound and thoroughly designed policies.

Since infant and child mortality rates are considered as indicators of poverty reducing them a part of a poverty reduction scheme requires provision of socio-economic infrastructures such as health, education, potable water supply and creating an enabling environment for women's economic empowerment.

In light with the results discussed in the previous chapter the following important policy implications are drawn.

It is found that access to improved water supply reduces both infant and child mortality. Thus policy makers and other stakeholders should give due attention for improving access to safe drinking water supply for it is strongly important in minimizing infant and child mortality. And further, improving water facility could help the country keep it self abreast of one of the Millennium Development Goals: *Reducing Child Mortality*.

However, the effects of improved water supply and availability of sanitation facilities per se could not be an assurance to bring reduction in child mortality. In view of the fact that the society

in the surveyed area has poor hygienic practice provision of sanitation facilities and safe drinking water become futile. Thus improving the society's awareness in health care and hygiene must be considered as a requirement to bring reduction in child mortality.

Moreover, we put forward that for the improvement of the health conditions of children in rural Ethiopia, first, it is necessary that the educational status of the population in general, and of mothers, in particular, should be improved, and second, the health services should be accessible and available at affordable cost for the promotion of health care practices. And further, maternal education programs have to create awareness on an early introduction of breastfeeding and should promote the importance of clean and full breastfeeding, for the introduction of supplementary foods at an early stage likely to make their children vulnerable to health hazards. Also awareness on the appropriate care that has to be taken when introducing supplementary foods must be created among lactating mothers.

Additionally, we found that in both infant and child mortality cases a child born to young and old aged women have faced high mortality risks while compared with a child born to mothers with age between 20 and 34(reference category). Thus we again put forward that the work that has been done to regard early marriage as unlawful should be strengthened since the psychological and reproductive maturity of mothers' during their first birth is believed to affect the survival chances of the infant/child. And also, old age mothers should be aware of the care that has to be taken to complement the frailty of the child due to maternal depletion.

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ANNEXES

Annex 1: Results of Multicollinearity Test, Infant Mortality Data

	Source_ Wat	Toilet_fac	Mother educ	Father_ educ	woman_ working	Child_twi n	Sex_ child	Breastfeedin g	Marital stat	Prec_birth inter1	Place_deliv
Sourced wat	1.0000										
Toilet_fac	-0.0302	1.0000									
Mother_educ	-0.0401	-0.1805	1.0000								
Father_educ	-0.1122	-0.1230	-0.3099	1.0000							
Woman_working	0.0329	-0.0452	0.0005	0.0244	1.0000						
Child_twin	0.1514	-0.0487	-0.3678	0.0744	0.0296	1.0000					
Sex_child	0.1039	-0.0425	0.1139	-0.0057	-0.0104	-0.0392	1.0000				
Breastfeeding	-0.1523	-0.0512	-0.0136	0.0727	-0.0283	0.0433	-0.0856	1.0000			
Marital_stat	0.0477	0.0383	0.0104	0.0492	0.0667	0.0115	-0.0217	-0.0068	1.0000		
Prec_birthinter1	-0.1385	-0.0768	0.1513	0.1397	0.0281	-0.0397	-0.0330	0.0618	-0.1405	1.0000	
Place_deliv	0.0145	0.0310	-0.0437	-0.0209	0.0029	0.0481	0.0295	0.0092	-0.0403	-0.0201	1.0000
Immunization	0.1213	-0.0400	-0.0238	-0.0318	0.0234	0.0817	-0.0677	-0.0159	-0.0830	0.0517	0.0292
Second Quantile	0.0268	0.0291	-0.0662	0.0523	0.0438	0.1280	-0.0104	0.0380	-0.0690	0.0214	0.0409
Middle Quantile	0.0089	0.0230	-0.0213	-0.0429	0.0213	0.1334	0.0126	0.0203	-0.1229	0.0623	0.0764
Fourth Quantile	-0.0080	0.0129	-0.0495	-0.0650	0.0284	0.1321	0.0387	-0.0127	-0.1151	0.0051	0.0300
Highest Quantile	0.0393	0.0059	-0.0128	-0.0776	-0.0625	0.0968	-0.0579	-0.1496	-0.1496	0.0538	-0.0005
Agemother_1stbirth1	-0.0444	0.0234	0.0003	-0.0616	0.0114	-0.1113	-0.0192	-0.1929	-0.1929	-0.1202	-0.0204
Agemother_1stbirth2	-0.0423	0.0341	0.0001	-0.0054	0.0132	-0.1220	-0.0231	-0.2032	-0.2032	-0.2453	-0.0341
Birth_order1	0.0689	-0.0651	-0.0772	0.0464	0.0747	0.2518	-0.0264	0.0442	0.0442	-0.2671	0.0242
Birth_order2	0.0210	-0.0365	0.0797	0.2590	0.0172	-0.1346	-0.0621	0.0409	0.0409	0.1161	-0.0152

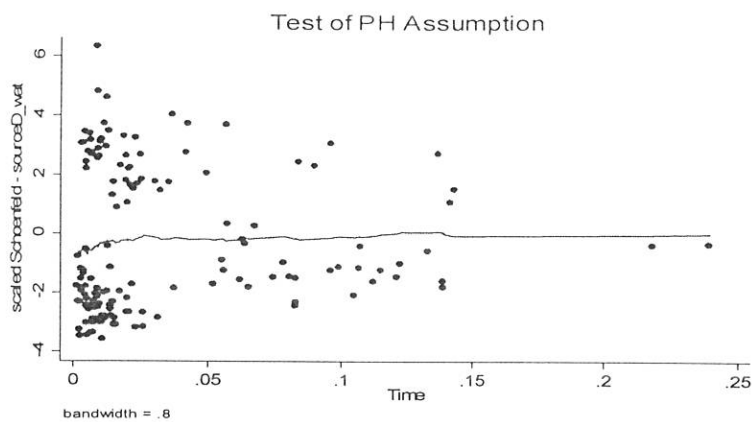
	Immunization	Second Quantile	Middle Quantile	Fourth Quantile	Highest Quantile	Agemother_at 1stbirth1	Agemother_at 1stbirth2	Birth_order1	Birth_order2
Immunization	1.0000								
Second Quantile	0.1265	1.0000							
Middle Quantile	0.0857	0.6593	1.0000						
Fourth Quantile	0.0339	0.6021	0.6092	1.0000					
Highest Quantile	-0.0071	0.6214	0.6397	0.6601	1.0000				
Agemother_at1stbirth1	0.0827	-0.0041	-0.0411	-0.0232	-0.0677	1.0000			
Agemother_at1stbirth2	0.0765	-0.0021	-0.0651	-0.0321	-0.0775	0.4531	1.0000		
Birth_order1	0.1270	-0.0167	0.0313	-0.0491	0.0252	0.0075	0.0135	1.0000	
Birth_order2	-0.0021	-0.0675	-0.0020	-0.0427	-0.0154	-0.2118	-0.1918	0.3516	1.0000

Annex 2: Results of Multicollinearity Test, Child Mortality Data

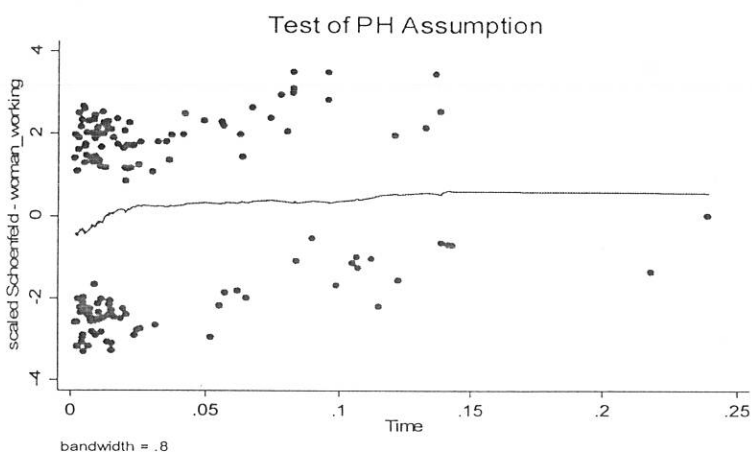
	Source_ Wat	Toilet_ fac	Mother_ educ	Father_ educ	Woman_ working	Child_ twin	Sex_ child	Breastfeed ing	Marital_ stat	Prec_birth inter1	Place_ deliv
Source_wat	1.0000										
Toilet_fac	0.0005	1.0000									
Mother_educ	-0.0156	-0.0449	1.0000								
Father_educ	0.0116	-0.0304	-0.2500	1.0000							
Woman_working	0.0072	-0.0175	-0.0155	0.0506	1.0000						
Child_twin	0.0265	-0.0512	-0.0331	0.0243	-0.0459	1.0000					
Sex_child	0.0464	-0.0230	-0.0054	-0.0057	0.0361	-0.0150	1.0000				
Breastfeeding	-0.0314	-0.0099	0.0420	-0.0273	-0.0724	-0.0610	-0.0309	1.0000			
Marital_stat	-0.0131	0.0568	0.0395	-0.0495	0.0671	0.0568	0.0081	-0.0381	1.0000		
Prec_birthinter1	0.0061	-0.0103	-0.0196	0.0052	-0.0367	-0.0261	-0.0203	-0.0400	0.0909	1.0000	
Place_deliv	0.0095	0.0268	0.0139	0.0093	0.0331	0.0200	0.0187	-0.0244	0.0079	0.0099	1.0000
Immunization	-0.0001	-0.0422	0.0044	0.0004	0.0317	-0.0070	0.0049	-0.0372	-0.0020	0.0159	-0.0491
Second Quantile	0.0700	-0.0293	-0.0036	0.0108	0.0448	0.0471	-0.0283	0.0010	0.0242	0.0222	-0.0009
Middle Quantile	0.0423	-0.0326	0.0073	0.0331	0.0276	0.0579	-0.0368	0.0186	0.0366	-0.0136	0.0250
Fourth Quantile	0.0647	-0.0662	-0.0122	0.0216	0.0204	0.0906	-0.0116	-0.0186	0.0097	0.0178	0.0181
Highest Quantile	0.0802	-0.0251	-0.0447	0.0375	0.0520	0.0747	-0.0325	0.0108	0.0449	-0.0191	0.0196
Agemother_at1stbirth1	-0.0303	-0.0041	-0.0196	0.0310	0.0073	-0.0003	0.0290	0.0186	-0.0786	0.0118	-0.0295
Agemother_at1stbirth2	0.0320	0.0071	0.0084	0.0221	0.0021	0.0024	0.0326	0.0375	-0.0021	0.0080	-0.0076
Birth_order1	-0.0527	-0.0092	-0.0524	-0.0254	0.0172	0.0808	-0.0017	0.0333	-0.0094	-0.3469	-0.0185
Birth_order2	-0.0014	0.0145	0.0304	0.1151	0.0017	-0.0587	-0.0576	0.0528	-0.0140	-0.1047	-0.0081

	Immunization	Second Quantile	Middle Quantile	Fourth Quantile	Highest Quantile	Agemother_ at1stbirth1	Agemother_ at1stbirth2	Birth_order1	Birth_order2
Immunization	1.0000								
Second Quantile	-0.0043	1.0000							
Middle Quantile	0.0244	0.6315	1.0000						
Fourth Quantile	0.0136	0.6115	0.6515	1.0000					
Highest Quantile	0.0196	0.5920	0.6334	0.6109	1.0000				
Agemother_at1stbirth1	-0.0010	0.0009	-0.0280	0.0043	0.0017	1.0000			
Agemother_at1stbirth2	0.0285	0.0353	0.0378	0.0378	0.0457	0.0483	1.0000		
Birth_order1	-0.0282	0.0363	0.0431	0.0134	0.0294	0.0533	-0.0475	1.0000	
Birth_order2	-0.0420	-0.0025	0.0191	0.0186	-0.0057	-0.0873	0.0053	0.4228	1.0000

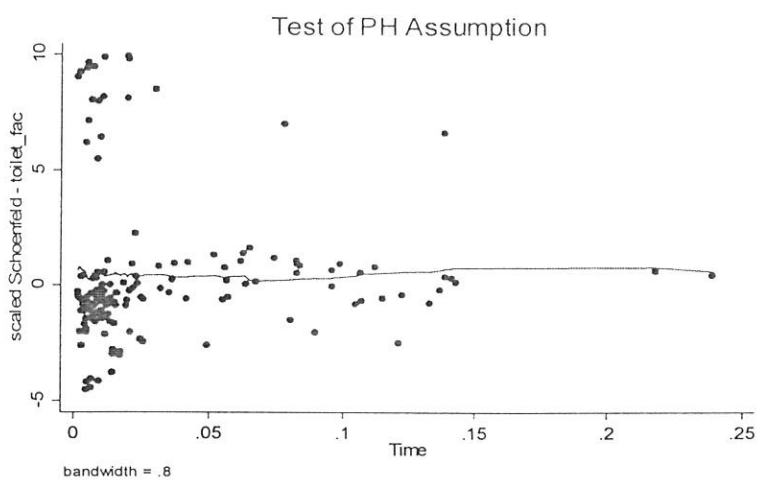
Annex 3. Test of the PH assumption for Source_wat, Infant Mortality



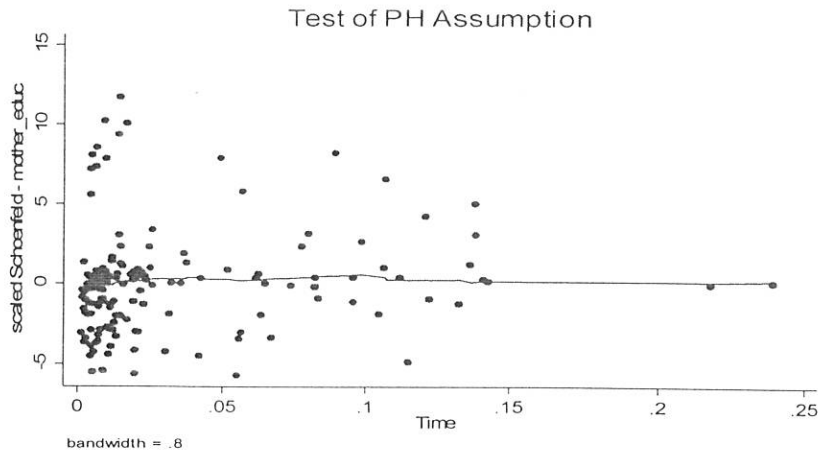
Annex 4: Test of PH assumption for Woman_working, Infant Mortality



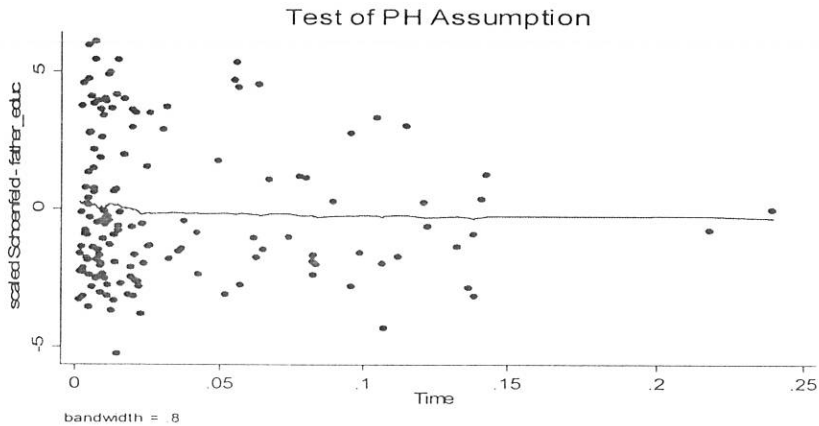
Annex 5: Test of PH assumption for toilet_fac, Infant Mortality



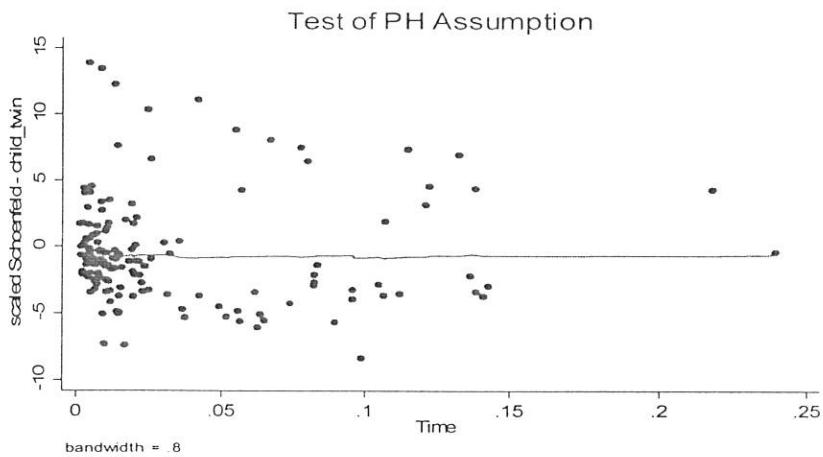
Annex 6: Test of PH assumption for mother_educ, Infant Mortality



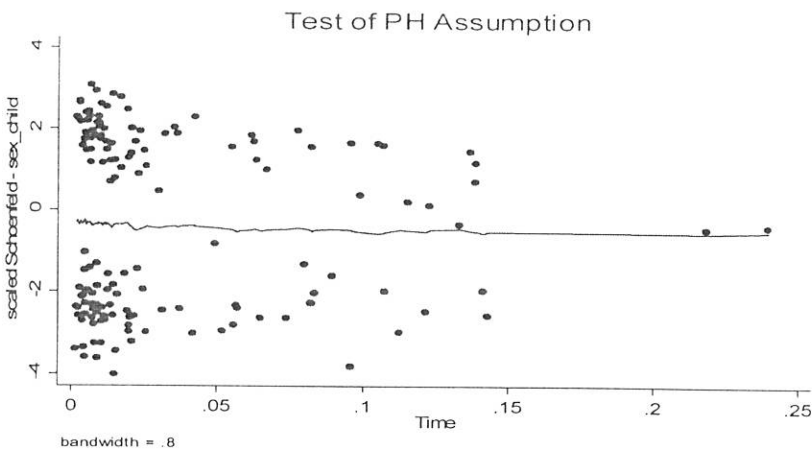
Annex 7: Test of PH assumption for father_educ, Infant Mortality



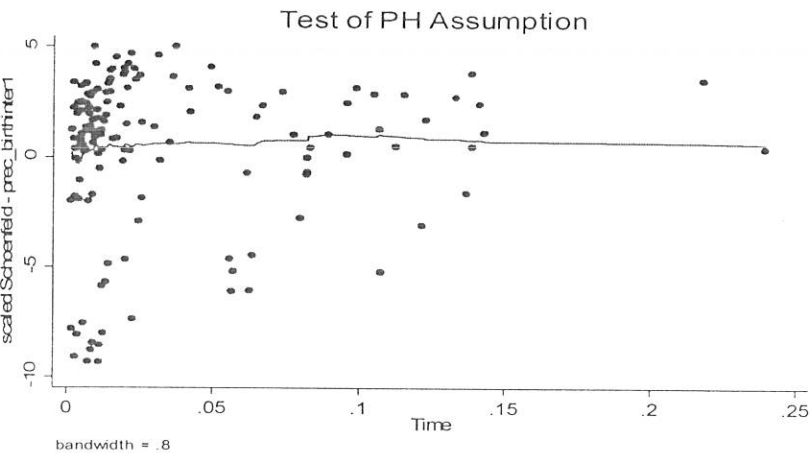
Annex 8: Test of PH assumption for child_twin, Infant Mortality



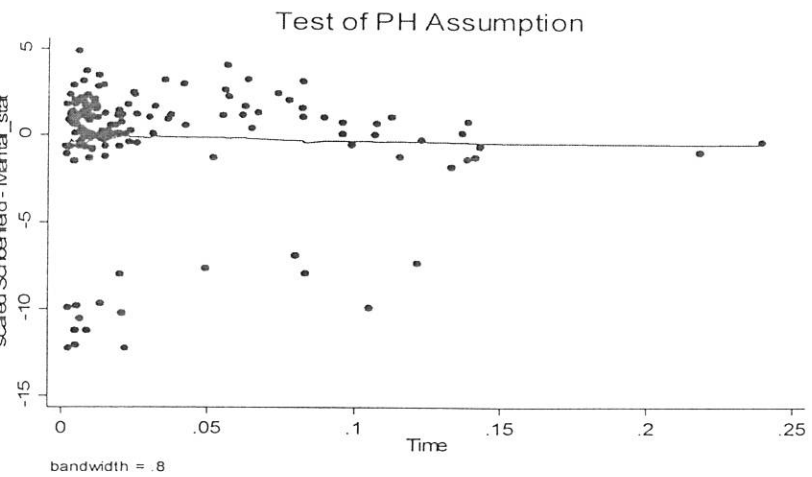
Annex 9: Test of PH assumption for sex_child, Infant Mortality



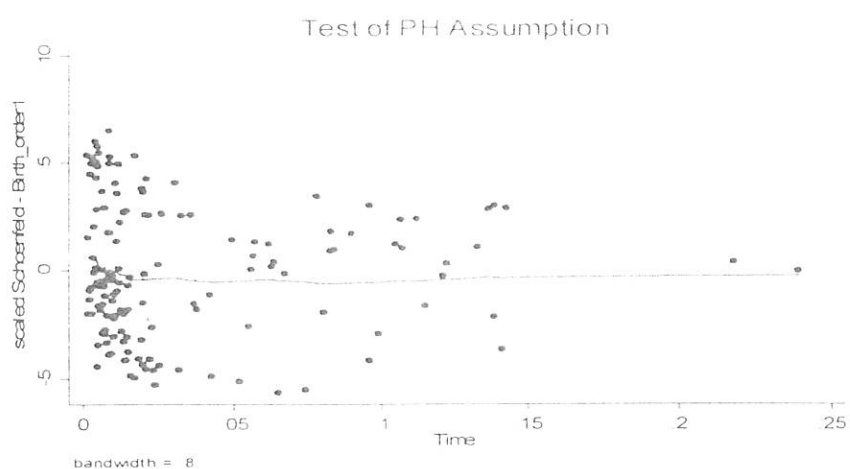
Annex 10: Test of PH assumption for prec_birthinter1, Infant Mortality



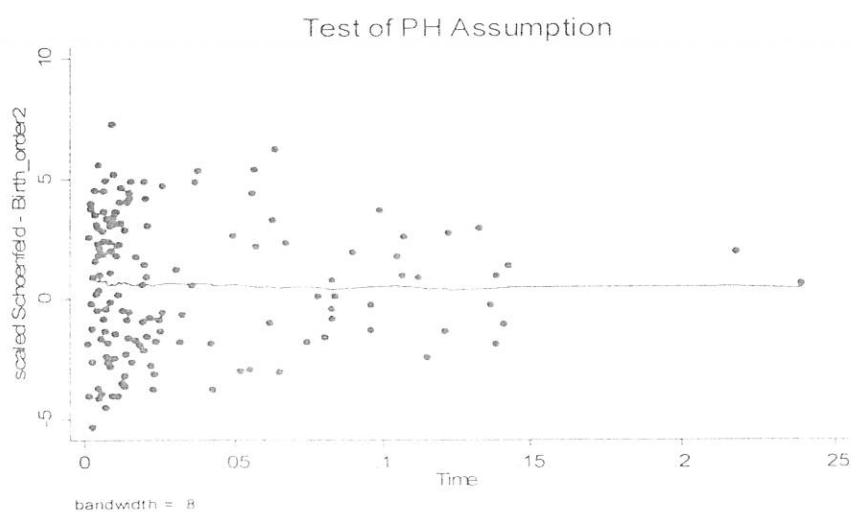
Annex 11: Test of PH assumption for Marital_stat, Infant Mortality



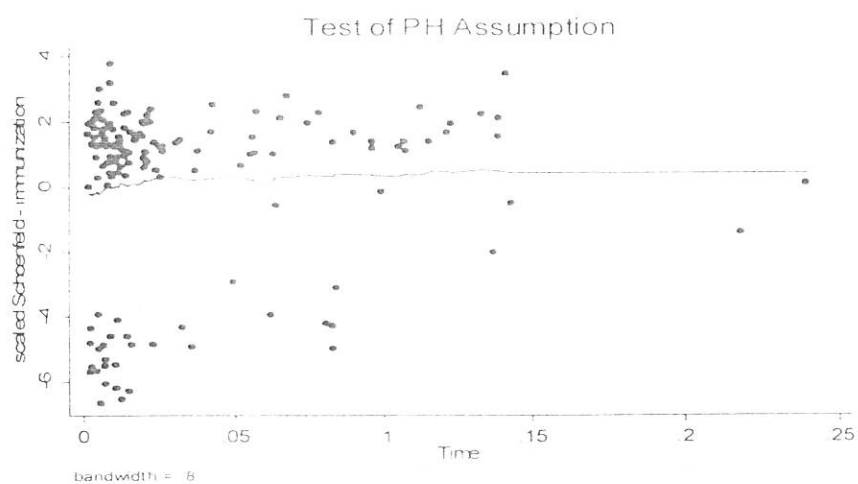
Annex 12: Test of PH assumption for Birth_order1, Infant Mortality



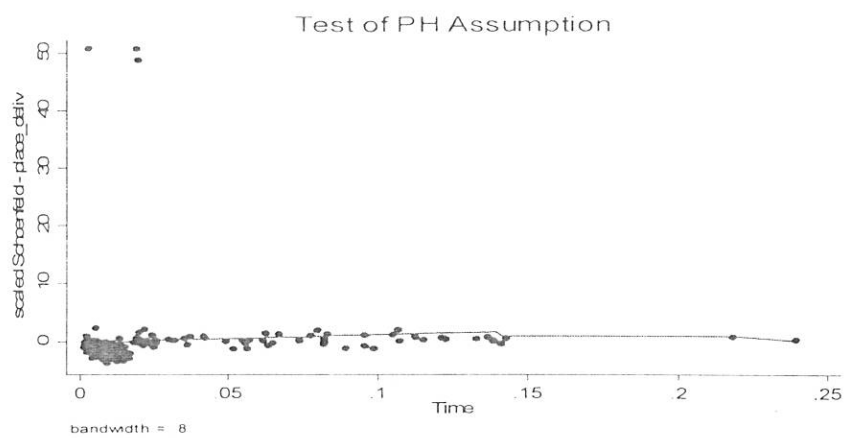
Annex 13: Test of PH assumption for Birth_order2, Infant Mortality



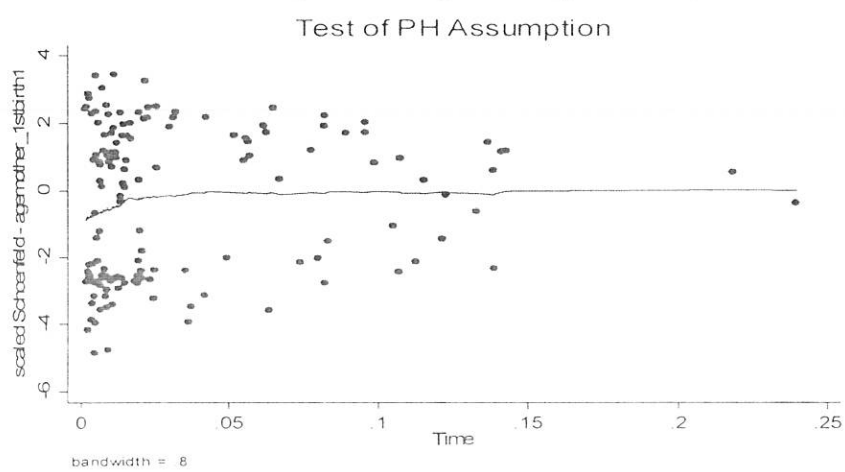
Annex 14: Test of PH assumption for immunization, Infant Mortality



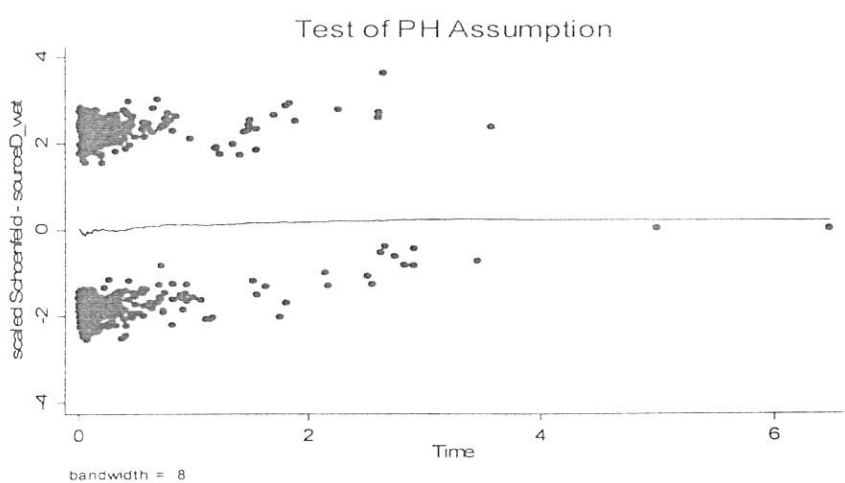
Annex 15: Test of PH assumption for place_deliv, Infant Mortality



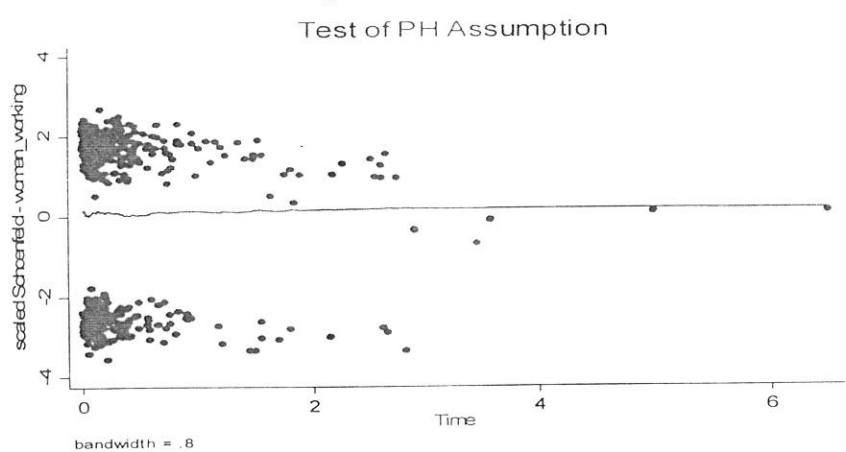
Annex 16: Test of PH assumption for Agemother_1stbirth1, Infant Mortality



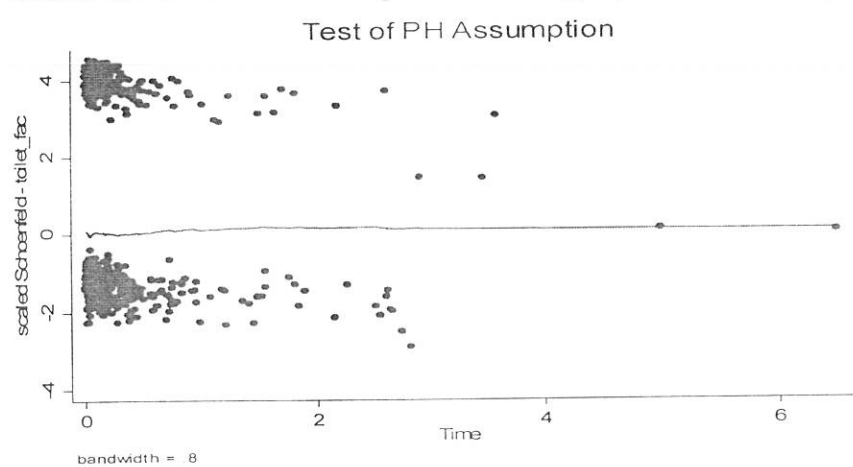
Annex 17: Test of PH assumption for Source_wat, Child Mortality



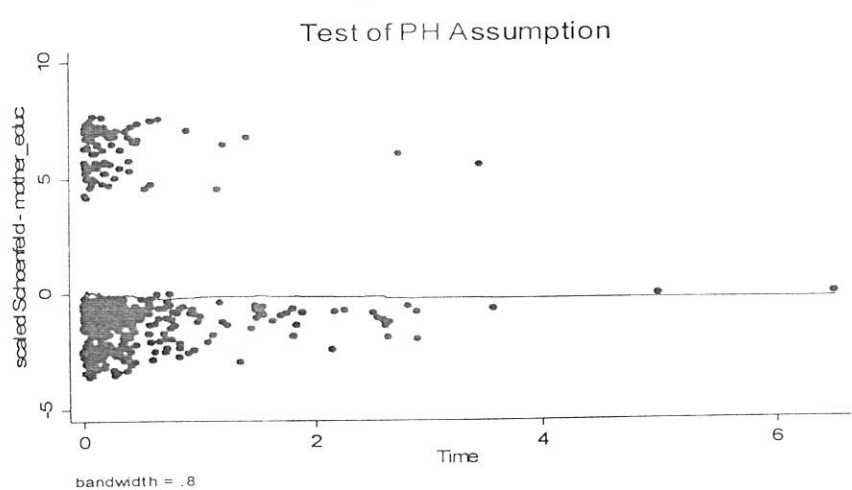
Annex 18: Test of PH assumption for Woman_working, Child Mortality



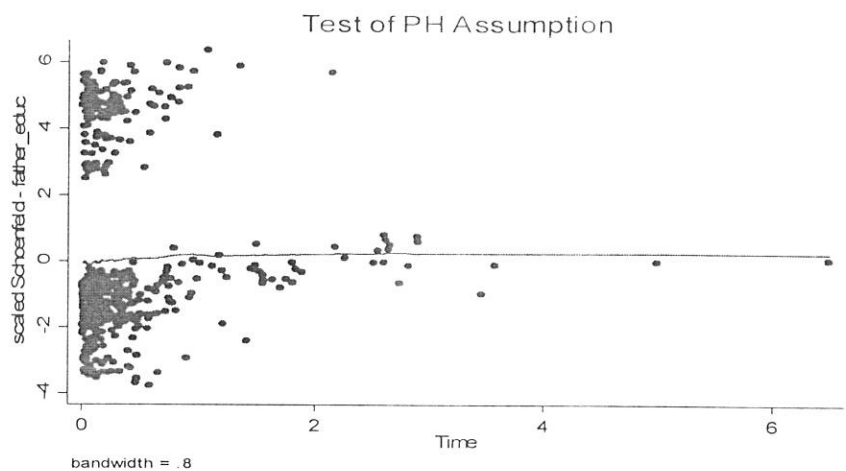
Annex 19: Test of PH assumption for toilet_fac, Child Mortality



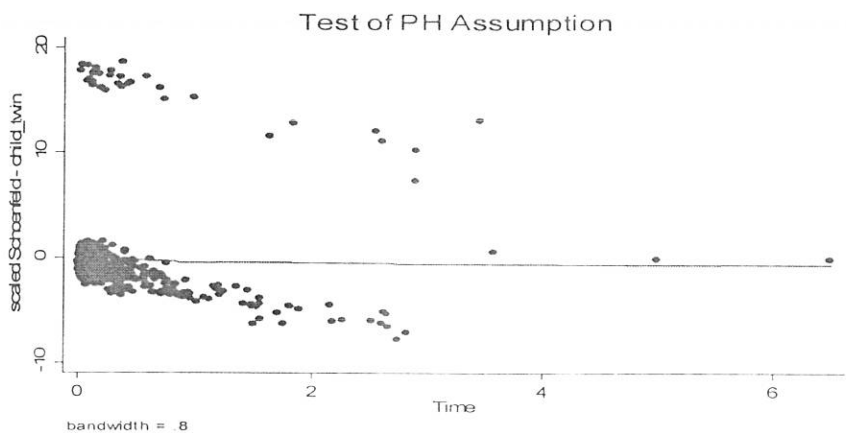
Annex 20: Test of PH assumption for mother_educ, Child Mortality



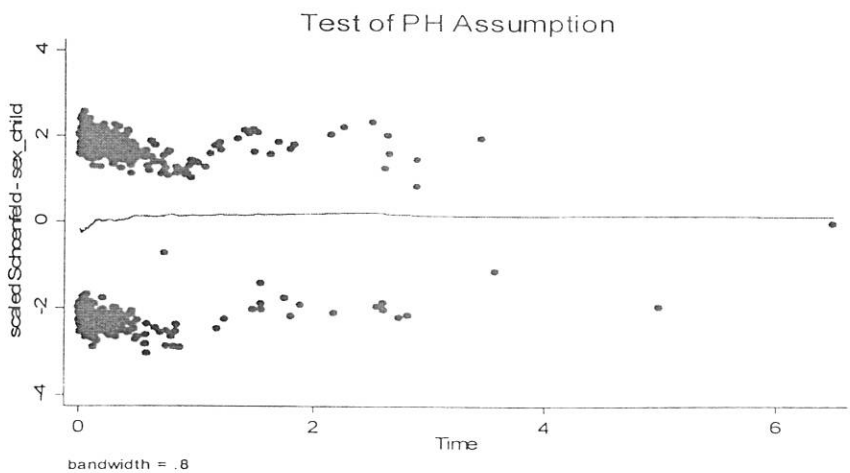
Annex 21: Test of PH assumption for father_educ, Child Mortality



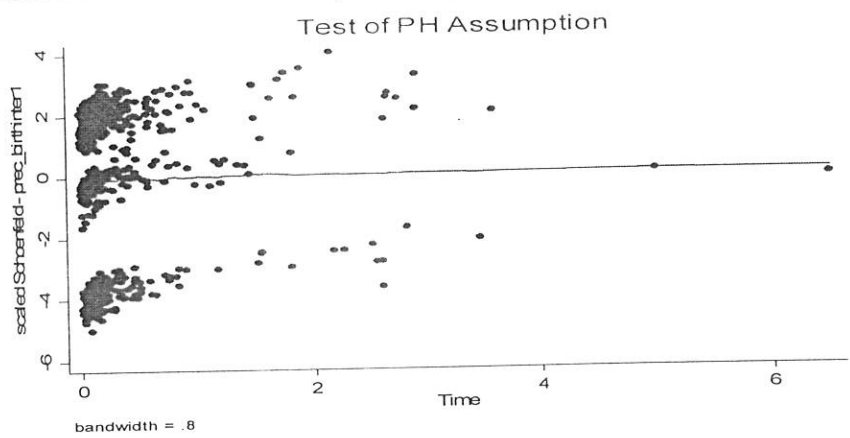
Annex 22: Test of PH assumption for child_twin, Child Mortality



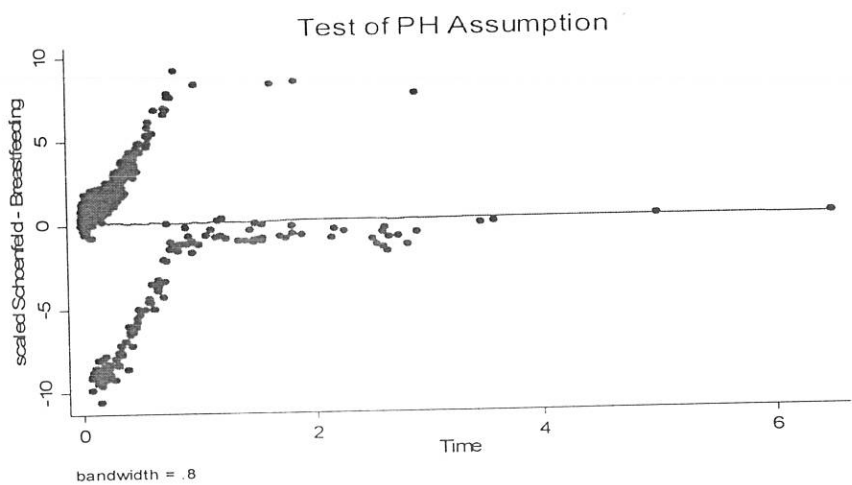
Annex 23: Test of PH assumption for sex_child, Child Mortality



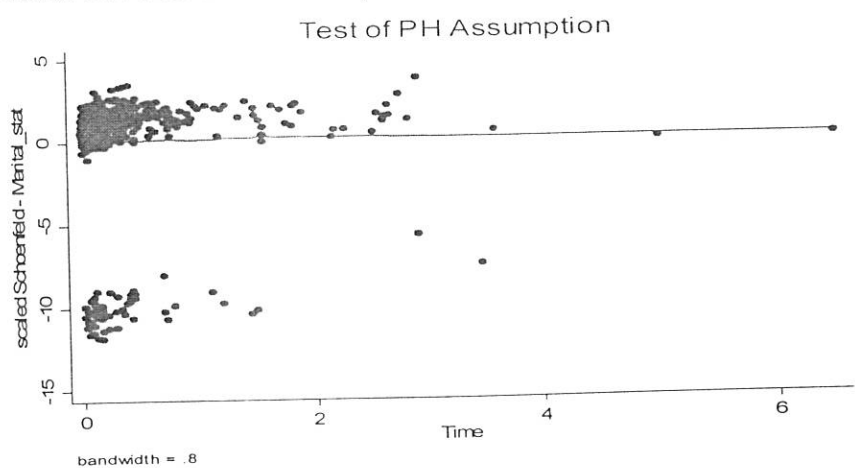
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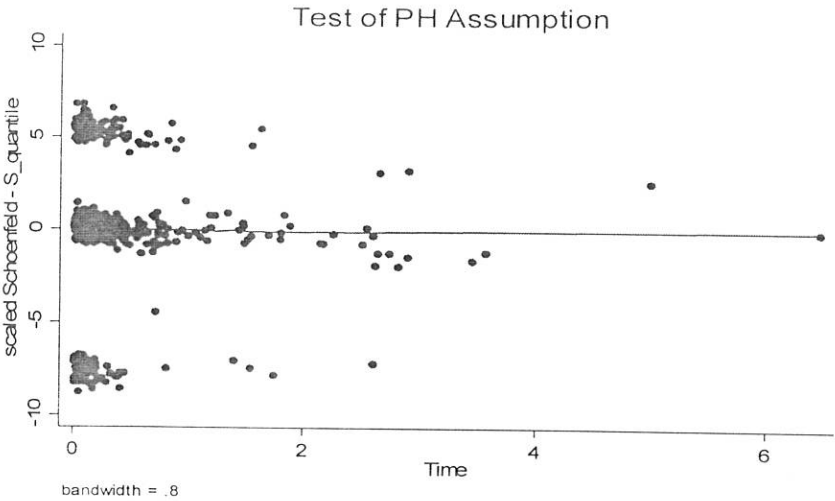
Annex 25: Test of PH assumption for Breastfeeding, Child Mortality



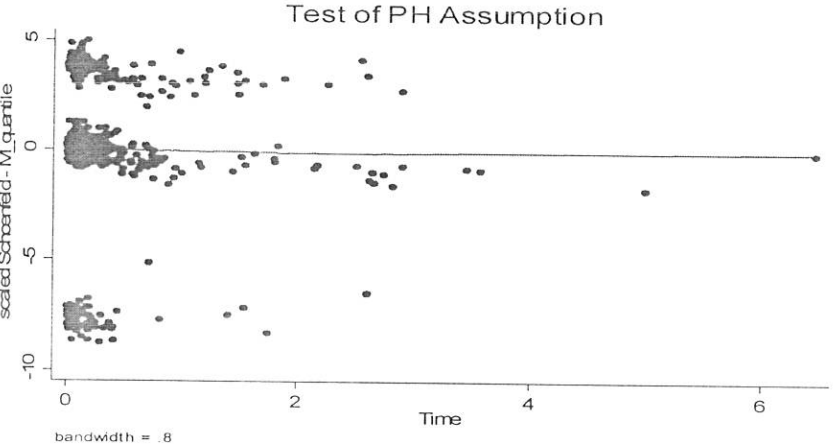
Annex 26: Test of PH assumption for Marital_stat, Child Mortality



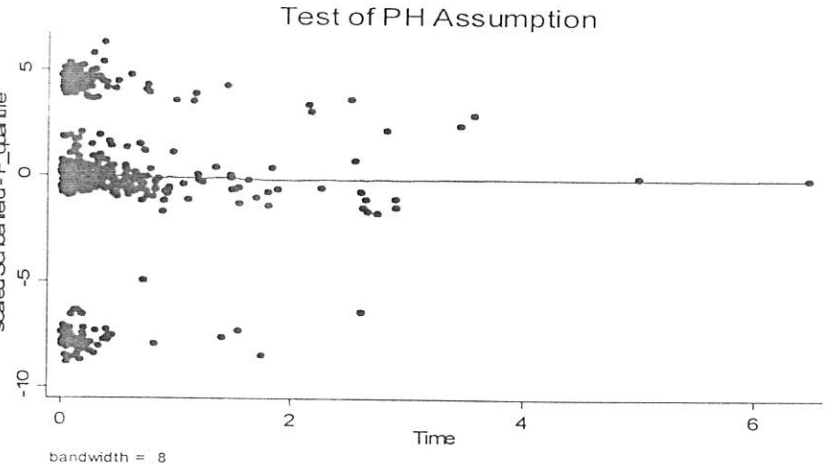
Annex 27: Test of PH assumption for S_quantile, Child Mortality



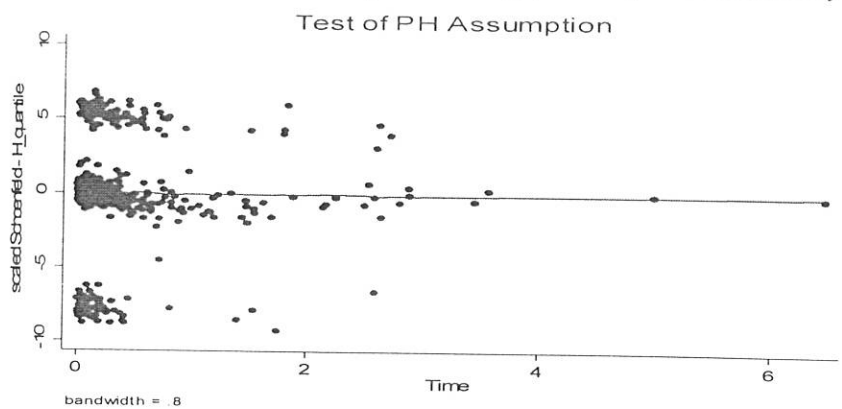
Annex 28: Test of PH assumption for M_quantile, Child Mortality



Annex 29: Test of PH assumption for F_quantile, Child Mortality



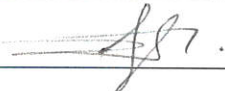
Annex 30: Test of PH assumption for H_quantile, Child Mortality



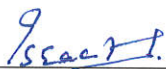
Declaration

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other university, and that all source of materials used for the thesis have been duly acknowledged.

Declared by:

Name: ZERIHUN GETACHEW
Signature: 
Date: July 28, 2006

Confirmed by Advisor:

Name: DR. ISSAC PAUL
Signature: 
Date: 28-8-2006.



Place and date of submission: ADDIS ABABA July 28, 2006