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The role of Maternal Health on Infant Mortality:

Evidence from the 2016 Ethiopian Demographic and Health Survey

by

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Abstract: Good maternal health care is essential for the survival and wellbeing of both the mother and her child. However, evidences on the impact of maternal health factors on infant survival are limited in sub-Saharan African countries. The main aim of the present study is to investigate the role of maternal health on infant mortality in Ethiopia using data from the most recent Ethiopian Demographic and Health Survey. The study employed both multivariate logistic regression and hierarchical models to analyze the data. The results of multivariate logistic regression depicts that all maternal health factors, except place of delivery, considered in the study are significant reflecting that the high infant mortality rate is partly due to poor maternal health in the country. The significant regional variation in family planning in the hierarchical model indicates that there is no equity in the allocation of scarce resources, particularly, maternal health facilities across the different regions of the country.

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List of Acronyms

ANC	Antenatal care
CBR	Crude birth rate
CDR	Crude death rate
CSA	Central Statistical Authority
DC	Delivery care
DHS	Demographic and Health Survey
EDHS	Ethiopian Demographic and Health Survey
HDSS	Health and Demographic Surveillance System
HSDP	Health sector development program
ICPD	International Conference on Population and Development
IMR	Infant mortality rate
MDG	Millennium development goal
MHB	Maternal health behavior
MMR	Maternal mortality rate
MOH	Ministry of Health
PHC	Primary health center
TBA	Traditional birth attendant
UNICEF	United Nations Children's Fund
USA	United States America
USAID	United States Agency for International Development
WHO	World Health Organization

1 Introduction

Maternal health is the health of women during pregnancy, childbirth, and the postpartum period. Good maternal health care is essential for the survival and wellbeing of both the mother and the infant (2016, EDHS). The health of mothers and infants is intricately related, hence preventing deaths requires implementing the same interventions which include such important measures as antenatal care, skilled attendance at birth, access to emergency obstetric care, adequate nutrition, post-partum care, infant feeding and care, and hygiene behaviors (UNICEF, 2009). Improving infant mortality is closely linked to advancing maternal health since it can reduce those who die during birth and ensure health in the early development stages of the infant's life (Shaw, 2006). However, the maternal health factors which can have a substantial impact on infant survival are overlooked and ignored (Maddux, 2001).

Infant mortality is the death of a young child before celebrating the first birthday, and it is measured by the infant mortality rate (IMR). Annual infant deaths have declined from 8.8 million in 1990 to 4.1 million in 2017 globally. That means, 4.1 million (75% of all under-five deaths) occurred in infancy in 2017 which could be prevented if good qualities of maternal health services were available (WHO 2019, Taddele 2010). Although there has been a substantial decline in infant mortality all over the world for the last two centuries, the global infant deaths remain high. According to Roster (2013), all countries in the world have shown effective progress against infant mortality over the last two centuries. As a result, the global infant mortality rate has dramatically been reduced by half from 43% in 1800 to 22.5% in the mid-20th century, and it has further been reduced by five-fold to 4.5% in 2015.

Because of the need for special attention to improve maternal health and reduce infant deaths globally, world leaders universally agreed the Millennium Declaration at the Millennium Summit in 2000 with the articulation of eight specific Millennium Development Goals (MDGs) (United Nations General Assembly, 2000). The International Conference on Population and Development (ICPD) in 1994 in Cairo also adopted the Program of Action focusing on population issues in the contexts of reproductive health and development (United Nations 1994). Maternal and child mortality was the major concern in both the ICPD Programme of

Action and the Millennium Summit, and improving maternal health and reducing deaths due to maternal causes were among the adopted goals and targets in both ICPD Program of Action and the MDGs (WHO, 2004). The ICPD Program of Action gives special attention to reproductive health of disadvantaged groups to improve socio-economic conditions of women in developing countries. It also addresses the economic conditions of poor women in developed countries (UNFPA, 1994).

There are huge cross-country variations in IMR in developing countries (76 per 1000 live births) as compared to that of developed countries which is only 5 per 1000 live births (PRB, 2011). According to You et al. (2010), Sub-Saharan countries, including Ethiopia, constitute the largest share of the global burden of infant deaths. However, many of these countries haven't been on the right way to achieve the target of the Millennium Development Goal-4 (reducing child mortality by two-third by 2015) (You et al., 2010). But, some countries having a very high infant rate in 1990, namely, Ethiopia, Malawi, Bangladesh, Timor-Leste, Nepal, United Republic of Tanzania, and Liberia achieved the target of the Millennium Development Goal-4. Ethiopia achieved the Millennium Development Goal towards IMR even three years before the planned year. The governments of Ethiopia, India, and USA, together with UNICEF, renewed the previously agreed the United nation Millennium Development Goal-4 on infant survival to redouble efforts further on infant survival and these countries launched an ambitious call to action towards reducing infant mortality rates to 10 in 1000 live births by 2030 (UN, 2015).

However, infant mortality is still very high in Ethiopia. The 2016 Ethiopian Demographic Health Survey (EDHS) report shows that 1 in 15 children in Ethiopia dies before reaching age 5, and more than 71% of the deaths occur during infancy. The government of Ethiopia has revised the previously nationally agreed sustainable goals towards lowering further infant mortality by 2030. In the process of responding against infant deaths in the country, quality evidence is required for health planners, policy-makers, and other bodies and organizations. The current study is, thus, aimed to contribute to the government's strategic plan against infant mortality by providing evidence-based information about proximate determinants of infant mortality linked to maternal health in Ethiopia.

Of course, several researchers identified the socioeconomic, demographic, and biological determinants of infant mortality in Ethiopia in the past two decades. However, to my knowledge, no study has been documented on the role of maternal health on infant mortality in order to be referred by decision-makers in the country. This study is, therefore, attempted to fill

this research gap by assessing the impact of maternal health factors on infant deaths using nationally representative samples of women in Ethiopia.

Definition of concepts

Live birth refers to the complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of the pregnancy, which, after such separation, breathes or shows any other evidence of life - e.g. beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles (WHO).

Maternal death is the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes.

Pregnancy-related death is defined as the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the cause of death.

Infant mortality rate is the probability of a child born in a specific year or period dying before reaching the age of one year.

1.1 Aim of the study

The main aim of this study is to investigate the role of maternal health on infant mortality in Ethiopia. The study further aims to see the variation in infant mortality across regions of the country.

Therefore, the current study aims to answer the following research questions:

1. What are the determinants of infant mortality linked to maternal health factors in Ethiopia?
2. Is there a considerable variation in infant mortality linked to maternal health characteristics among the different regions of Ethiopia?

1.2 Outline of the Thesis

This thesis is organized in to five chapters. The first chapter introduces the research problem. Chapter two describes backgrounds of the study area; the theoretical framework used and reviewed literatures. The third chapter discusses about data and methodology used in this study. Results and discussion are presented in Chapter four. Conclusions and policy implication follow in chapter five.

2 Background and Theory

2.1 Background of the study area

Ethiopia is a landlocked country located in Eastern Africa which is classified as sub-Saharan African country and it is the oldest independent country of Africa. The country is known to be the cradle of mankind, the origin of Homo sapiens. It is known to be the largest and most populated country in the Horn of Africa and it ranks the 2nd populous country in Africa next to Nigeria with a total population of more than 105 million in the year 2017 (World Bank, 2018). Ethiopia shares its border with a total of 6 countries: Djibouti, Eritrea, Kenya, Sudan, Somalia, and South Sudan. According to the WHO data published in 2018, life expectancy in Ethiopia is 65.5 with a median age of approximately 17.9 years of age and about 60% of the population is under the age of 25 implying that the majority of the population constitutes young people.

Ethiopia is a Federal Republic with nine regional states, two administrative cities, 770 Woredas (the third-level administrative divisions next to district), and 15,000 Kebeles (districts) having variations concerning the standard of living and socio-economic conditions. The country has more than 86 ethnic groups having their languages and cultures. The capital of Ethiopia is Addis Ababa, meaning "new flower" in Amharic which is the national language in the country.

Ethiopian is among the least developed countries in the world with average economic growth of 10 % since 2005, an estimated 24 % of Ethiopians live below the poverty line in 2016 (World Bank, 2020). Ethiopia ranks 173rd of 189 countries in UNDP's 2019 Human Development Index with the category of low human development. The Ethiopian economy is mainly dependent on agriculture which hire 85 % of the total population and generates more than 40 % of the country`s GDP (MOFED, 2014). The Government follows a market–based and agricultural led to industrialization economic policy. Currently, the country is struggling to ensure economic revolution from an agricultural to the industrial led economy. There have been a number of policy initiatives and measures taken in these directions which included privatization of state enterprises and liberalization of government regulations and the health sector is playing its counterpart as a means of economic growth (MOH, 2015).

The health system of Ethiopia has been directed by a 20 years Health Sector Development Programme (HSDP) which has been further divided into four series of five-year HSDPs I to IV commencing in 1997. HSDP IV was the final phase of HSDP and ended in June 2015. Currently, the Health Sector Transformation Plan (HSTP) is another five-year national health sector strategic plan, which covers July 2015 – June 2020. It has been prepared by conducting in-depth situational assessment and performance evaluation of the former HSDP.

Maternal and newborn health is poor in Ethiopia though they are priorities for the Government of Ethiopia (MOH, 2015). Approximately 30 percent of households were estimated to live more than 10 kilometers from the nearest hospital, health center, or health station. Besides, most facilities have inadequate supplies of drugs and equipment, poor equipment maintenance, and a deteriorating infrastructure (Saharty, 2009).

The number of skilled health personnel per 10,000 population is a proxy measure for the provision of maternal health services, and a strong indicator of the strength of systems and commitment of the government to the health of its citizens (UNICEF, 2019). WHO standards call for a minimum of 44.5 doctors, nurses, and midwives per 10,000 population. However, human resources for health in Ethiopia are one of the lowest in the world. With the inclusion of health extension workers, Ethiopia had 11 health workers per 10, 000 population by 2011 which is very far from the WHO minimum standard mentioned above (FMOH, 2012).

Several strategies have been used to improve health service deliveries in the country. Decentralization of authority and accountability of managing health services to sub-national levels was the main strategy among all. Under Ethiopia's federal government system, the Regional Health Bureau at the State level is the main managerial body in charge of the overall management of the country`s health system. Within each Regional State, there is a network of administration structures that includes Zonal Health Departments and district level health offices. Each Regional Health Bureau is both administratively and financially responsible for health care delivery and receives a considerable share subsidy from the Federal Government every year.

Similar to other sub-Saharan African countries, both birth and death rates were very high in Ethiopia as compared to the global average in 2005 (20.5 and 8 per 1,000 respectively) (see figure 2.1 below). It seems that the country is in the third stage of demographic transition as fertility declines substantially followed by a decline in mortality leading together to a low

population growth rate in the country. As shown in the figure, the birth rate has been reduced greatly in Ethiopia since the 1990s. It can be illustrated from the figure that much work is still left for the government of Ethiopia to enter the fourth demographic transition as it has been accomplished by other developed countries.

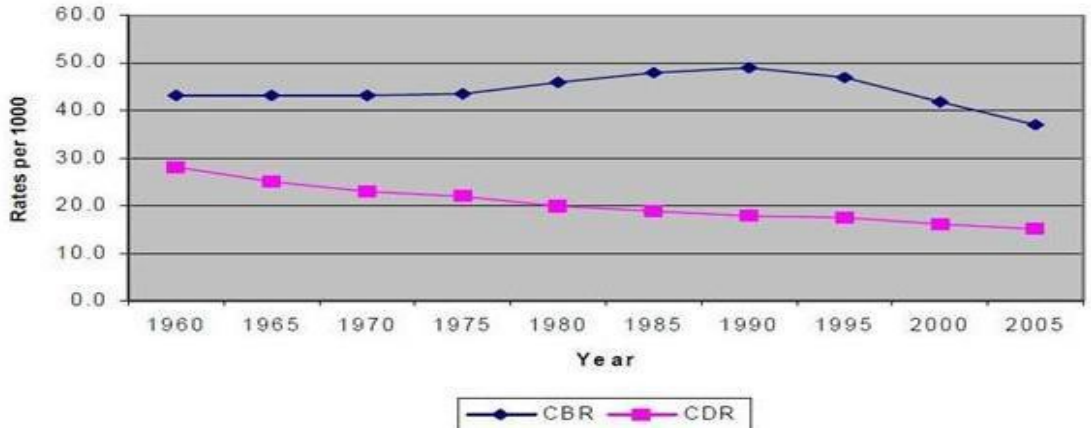

Figure 2.1: *Trends in CBR and CDR: 1960-2005 (*CSA, 1984, 1994 PHC)

According to the 2016 EDHS report, fertility varies significantly between urban and rural areas, specifically, the average fertility rate in the rural parts of Ethiopia is 5.2 whereas women in urban parts have an average of 2.3 children whereas the national average is 4.6 children per woman. The report also indicates that fertility rates vary by geographical regions, i.e., the fertility rate is 1.8 children per woman in Addis Ababa (lowest) and it is 7.2 children per woman in Somali (highest). Furthermore, Fertility levels are much lower among highly educated women and women living in the capital city, Addis Ababa (EDHS, 2016).

Furthermore, the 2016 EDHS report also reveals that a 50% reduction in infant mortality has been shown in Ethiopia in the last 16 years which corresponds to a decline in infant mortality rate from 97 deaths per 1,000 live births in 2000 to 48 deaths per 1,000 live births in 2016 (see figure 2.2 below), however, 48 deaths per 1,000 live births shown in 2016 is still far from the global average (30.6 deaths per 1,000 live births) in 2016 implying that further reduction in infant mortality is necessary in the country. The report also reveals that there are variations in infant mortality among the socioeconomic and demographic characteristics, for instance, IMR was higher for less-educated women, women with lower than 2 years of birth interval, and women residing in the Afar region in the country (EDHS, 2016).

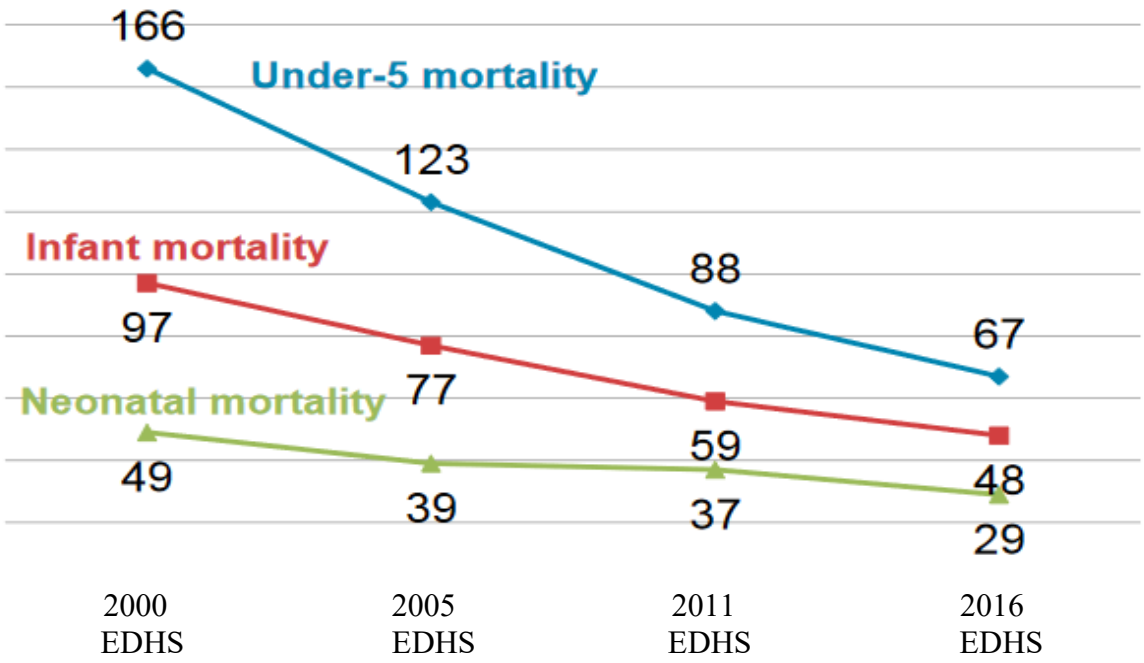

Figure 2.2: *Trends in IMR: 2000–2016 (2016 EDHS)*

On the other hand, maternal health indicators have increased to some extent for the past two decades in Ethiopia. The proportion of women age 15-49 who received ANC at least once from a skilled provider has increased from 27% in 2000, to 28% in 2005, 34% in 2011, and 62% in 2016 (EDHS, 2016). Antenatal care can be defined as the care provided by skilled health care providers to pregnant women and adolescent girls in order to ensure the best health conditions for both mother and baby during pregnancy (WHO, 2016). Higher-order births are less likely to receive ANC than lower-order births.

2.2 Theoretical Approach

2.2.1 Theory of Demographic Transition

Currently, the existence of a causal relationship between infant mortality and fertility has been the subject of debate among demographers. And, most mortality-fertility postulates are based on different theories, like demographic transition theory. Demographic transition has been the most important topic in modern demography in the long years of population studies. Demographic transition is one of the best-documented generalizations in the social sciences.

Warren Thompson formulated demographic transition models for the first time which was published in 1929. He formed three different groups of countries based on their population growth rates and saw the demographic transition in each group. Similar to Thompson`s three groups, Landry postulated three stages of population development which include, primitive, intermediate, and contemporary. Landry presented a much detailed explanation Thompson of the phases of the demographic transition. However, Landry's study limited to France. A.M. Carr-Saunders wrote a book 1936 named as *World Population: Past Growth and Present Trends.* He explained about population side and demographic change in several countries. Due to data limitation he considered only Europe and overseas countries having populations of European background. Demographic transition theory was coined by Frank W. Notestein for the first time in the mid 20 century. Office of population research formulated the demographic transition theory in Princeton as a culmination of previous research conducted by Notestein's and it was published on behalf of the League of Nations in 1944 (Notestein et al, 1946).

The demographic transition theory is an aggregate explanation of the changing patterns of fertility, mortality, and population growth rates as societies move from one demographic regime to another regime over time. According to Notestein, as shown in figure 2.3 below, the demographic transition can be described in four different stages. The first demographic transition stage (pre-modernization) is characterized by high birth rates and death rates with a low population growth rate as a result of late age at marriage, famine, war, etc. During the second demographic transition stage (early modernization), mortality started to decline while birth rates remained high which caused the world population to grow rapidly. In the third demographic transition stage (late modernization), birth rates began to decline resulting in the deceleration of population growth. The last demographic transition stage is named as post-modernization.

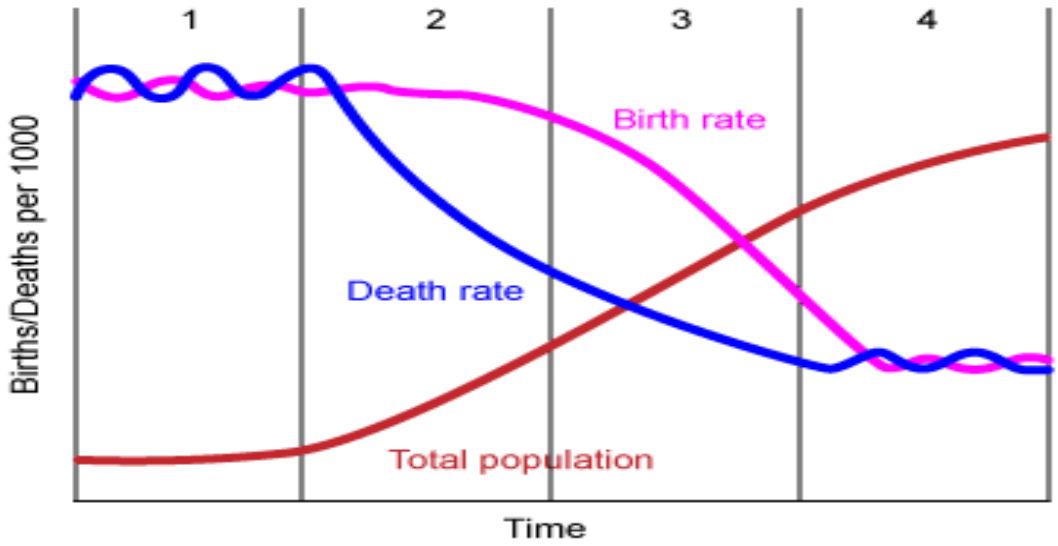

Figure 2.3: *Global demographic transition*

Fertility and maternal health are highly associated, with high fertility levels associated with high maternal mortality. Essential linkages exist between maternal health, infant mortality, and family planning in Ethiopia. Before modernization, according to the demographic transition theory, societies are characterized by high mortality and fertility levels. However, mortality rates decline first and as development continues, fertility levels follow as a result of improvements in health and living conditions (WHO, 2004). The use of contraception, educational levels of women, and women's status have a substantial impact on maternal health through reducing fertility (Angeles, 2004; Bulatao and Ross, 2003; Hakim, 2003; Midhet, 1998). The use of contraception is important to limit the number of children in a family and lowers levels of fertility. More educated can have a better knowledge of the use of contraception and afford the cost of health service utilization. Besides their influence on maternal mortality through lowering fertility, women's status in the society and education were found to significantly impact maternal mortality (Mousa and Madi 2004; Shen and Williamson, 1999; Bongaarts, 2003).

Demographic changes vary greatly across the different regions of the world, especially, the fertility rate is still very high in Sub-Saharan African countries (see figure 2.4 below). On average, married couples have at least 5 children in the region which is very far from the current world average fertility rate (2.448 births per woman). This high fertility rate is an indication of backwardness and poor technological improvements in the region mainly in the area of maternal and child health such as ineffective family planning. Such high birth rates can cause high

maternal and infant mortality to occur. As the region is less developed and there are poor health systems, the highest share of such mortality affects vulnerable groups, and maternal and infant mortalities remain very high in the region.

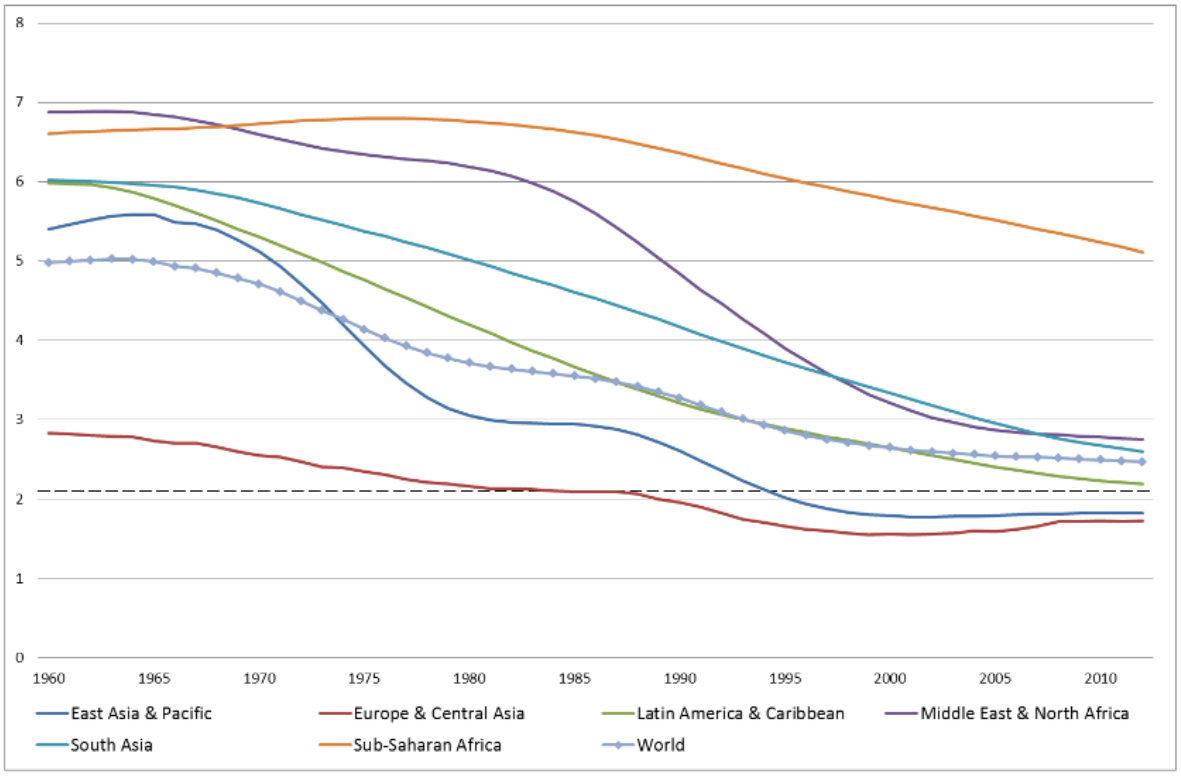

Figure 2.4: *Total fertility rate (World Bank)*

2.2.2 Modernization Theory

Postulates of the modernization theory claim that industrialization reduces infant mortality through economic growth and improvements in the medical sciences which introduced the use of varieties of modern and effective contraceptive methods (Rostow, 1960; Frey and Carolyn, 2000). According to Frey and Carolyn (2000), the promotion of industrialization is less likely to be an effective means for lowering infant mortality in the less developed countries. Rather, policies promoting economic "re-articulation", reductions in foreign debt, and female education seem to be the major contributors to the reduction in infant mortality in these nations since educated women are more likely to use effective contraception and maternal health services during pregnancy and delivery than less educated ones.

Furthermore, preterm births and neonatal disorders constitute 12% of global infant deaths and considered the second most common cause of infant mortality in the world (Roser et al, 2013). Roser et al (2013) also investigated that modernized countries with excellent health systems have 10-times lower infant mortality rates than the world average which clearly shows that the vast majority of these infant deaths are preventable reflecting that high infant mortality in poor countries is linked to underdevelopment situation of these countries.

Being Ethiopia one of the least developed countries in the world, in the same reasoning as stated above, it seems that very high infant mortality rate in Ethiopia is partly due to neonatal disorders which can be manifested by the shortage of skilled manpower and less advanced medical technologies in the country whereby women have no efficient access to health services during pregnancy and delivery. Startling

2.2.3 Gender Stratification Theory

Postulates of gender stratification theory focus on inequalities in power and privilege between males and females (Mason, 1986). Since an increase in women´s employment, education, nutrition, and health care decrease infant mortality, improvements in women`s status can reduce infant mortality; however, increased female education appears to be one of the most important means of reducing infant mortality (Caldwell, 1993). According to Caldwell (1993) reasoning, educated mothers are more likely to seek health care for their children; a literate mother is more likely to be able to communicate with health care providers; female education has positive effects on the balance of family relationships regarding child care. Existing cross-national research provides strong support for the gender stratification argument that advances in female education (and other forms of women status) reduce infant mortality (Boehmer and Williamson, 1996; Kabagarma and Mulford, 1989; Pattnayak and Shai, 1995; Shen and Williamson, 1997; Subbarao and Raney, 1995).

According to the gender stratification theory, as a woman becomes more educated and powerful, she is more likely to independently decide on her health matters regardless of the decision of her husband/partner as she may have the required knowledge about maternal health issues. And, she can have access to health facilities and can afford herself the cost of her health expenditures including costs related to maternal health during pregnancy. Therefore, it is reasonable to say that such women`s empowerment is important for investing in their health,

including during pregnancy which is in turn important for getting healthy birth outcomes that can lower infant deaths.

2.2.4 Maternal and infant mortality rates as a measure of development

According to WHO (2004), complications during pregnancy and childbirth are the main cause of death and disability among childbearing women in less developed countries. The maternal mortality ratio represents the risk associated with each pregnancy, and it is also a Millennium Development Goal indicator (WHO, 2004). The health of women, mothers and children is crucial to development (Amiri and Gerdtham, 2013). The finding of Amiri and Gerdtham (2013) confirms a strong association between GDP and maternal and child health outcomes, and the magnitude of the effect of GDP on maternal and child health outcomes in low-income countries is larger as compared to high-income countries. The level of economic development is one of the most influential factors of a nation's mortality rate including maternal mortality ratio (the risk associated with each pregnancy per 100 000 live births) and infant mortality rate (Firebaugh and Beck, 1994; Pritchett and Summers, 1996). There are evidence on the relationship between the level of socio-economic development and maternal and infant health indicators. There exist a huge difference in maternal mortality ratios between developed and developing countries (UNICEF/UNFPA/WHO, 2004). The differences between income groups within countries are also substantial. Studies carried out in different economic settings show that poor women are more likely to die in childbirth than rich women (Graham and others, 2004; Mayor, 2001). These studies nurtured concerns about setting of international goals as societal averages because the differences between the rich and poor populations could be ignored (Gwatkin, 2002).

Very high maternal mortality rates can affect investment through rates of return in less developed countries. In a country where resources are scarce and maternal and infant health are free of charge for its citizens like the case of Ethiopia, high mortality rates result in huge government expenditures while there is very little return to investment due to infant deaths. Such a situation greatly affects the growth and development of a nation and aggravates poverty. For a particular case of Ethiopia, malnutrition alone contributes to more than 50 percent of all infant and child deaths in the nation (USAID, 2017). The World Food Program (WFP), in its report entitled "The Cost of Hunger in Ethiopia", revealed that a very large percentage (about 81%) of all the reported malnutrition cases go untreated, consequently 28% of children younger

than 5 dies from malnourishment every year in Ethiopia. These results are by far much larger than in other Sub-Saharan African countries (Ewusie, 2017). The WFP report also showed that malnutrition is not only a serious health issue in Ethiopia but also it aggravates poverty as the country loses around 16.5% of its GDP each year to the long-term effects of child malnutrition, which adds an extra burden to the country considering that Ethiopia is one of the poorest countries in the world. This very high infant mortality reflects the poor health management of the country and it further illustrates the impact of high infant mortality on the growth and development of the nation.

The maternal mortality rate is used as a good measure of a country's health system. It can be, in general, used as a good measure of the quality of life in a given country (Stroobant, 2001). A very low maternal mortality rate in the industrialized world is an indication of good health care systems, economic advancement, and a good standard of living in these countries. On the contrary, very high maternal mortality rates in less developed countries reflect ineffective health policies and poor socioeconomic status.

Moreover, using Instrumental variables estimation, Pritchett, L. and Summers, L. (1996) found a huge impact of income growth on health using cross-countries and time-series data. Using infant mortality and life expectancy as measures of a country´s health performance, they confirmed that wealthier nations are healthier.

2.2.5 Analytical Framework

Different researchers used different conceptual frameworks to study mortality rates. The traditional approach of studying infant mortality through maternal characteristics in social science research focuses on assessing the association between the trends and patterns of infant mortality and socioeconomic status of women in a population. However, this approach couldn't incorporate other medical causes of infant deaths. As a result, scientists in the social science couldn't determine the complete causality between socioeconomic status and infant mortality as there was omitted variable bias since the mechanisms by which socioeconomic determinants operate to produce the observed mortality inequalities left unexplained.

Mosley and Chen (1984) is the most widely used modern analytical approach to identify the proximate and socioeconomic determinants of infant mortality in developing countries. This approach categorized the determinants of infant mortality as exogenous (socioeconomic) such

as cultural, socioeconomic, community, and regional determinants and endogenous (bio-medical) such as maternal, environmental, nutrition, injuries, and personal illness. In this approach, socioeconomic determinants affect indirectly infant mortality, they operate through the proximate determinants while proximate determinates affect infant mortality directly (Mosey and Chen, 1984; Schultz, 1984). Mosley and Chen`s (1984) approach group fourteen proximate determinants of infant mortality into five general categories (see figure 2.5 below).

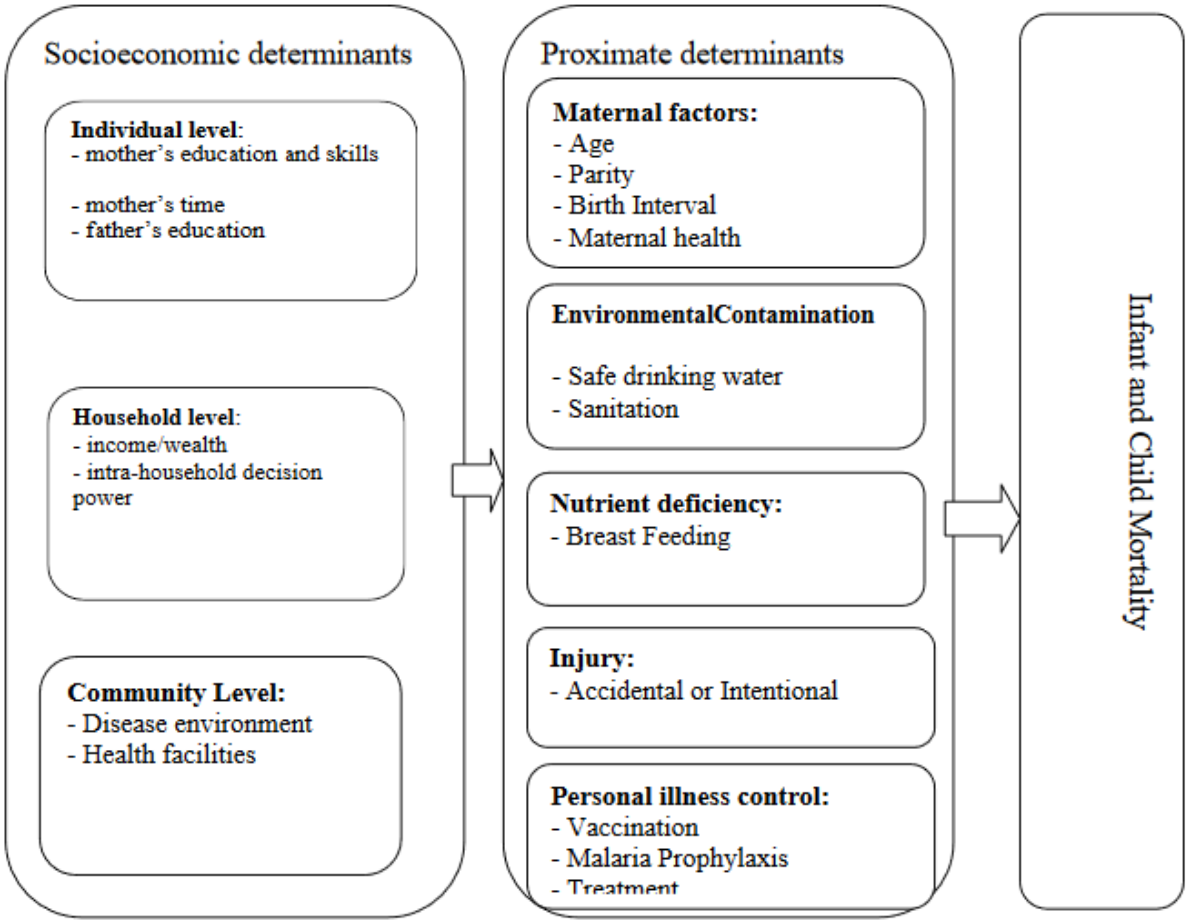

Figure 2.5: *Conceptual framework (*Based on Mosley and Chen (1984) theoretical framework*)*

The proximate and socioeconomic determinants assume the following five premises:

1. In an optimal setting, over 97 percent of newborn infants can be expected to survive through the first five years of life.
2. Socioeconomic determinants must operate through more basic proximate determinants that in turn influence the risk of disease and the outcome of disease processes.
3. Reduction in this survival probability in any society is due to the operation of social, economic, biological, and environmental forces.

4. Growth faltering and ultimately mortality in children are the cumulative consequences of multiple disease processes (including their biosocial interactions). Only infrequently is a child's death the result of a single isolated disease episode.
5. Specific diseases and nutrient deficiencies observed in a surviving population may be viewed as biological indicators of the operations of the proximate determinants.

The current study uses the conceptual framework developed by Mosley & Chen (1984) which was designed for the study of the determinants of child survival in developing countries. As it can be seen from the previous theories, infant mortality is indirectly associated with several factors such as education, income, and health facilities. These factors can affect the health conditions of mothers which in turn determine the health of infants. The previous theories reflect that, in recent times, improvements in the socio-economic conditions and development of human being are shifted to better health, especially maternal heath. The current framework uses the framework developed by Mosley & Chen (1984) that link the different factors associated with infant mortality in such a way that maternal health is directly linked to the death of infants which makes more sense for developing worlds where mortality is higher.

This study is done in one of these developing countries, Ethiopia. As discussed in the background section, infant mortality is high in Ethiopia and the country's health system is poor where a considerable portion of women's population haven't access to quality health facilities. Therefore, it would be reasonable to apply the Mosley & Chen (1984) framework in such high mortality and scarce resource setting.

2.3 Previous Research

There have been extensive empirical and theoretical works on the high rate of maternal and infant deaths during pregnancy, childbirth, or in the immediate postpartum period in different socio-economic settings. Evidence show that the lifetime risk of death due to pregnancy-related complications is 250 times higher among women in developing than in developed countries (Yanagisawa et al, 2006). These risks are linked to socioeconomic, reproductive, and health service factors.

There are many mechanisms through which maternal death can lead to infant death. The most common causes of maternal mortality are associated with obstetric complications which include

sepsis, eclampsia, obstructed labor, and hemorrhage put infants at higher risk of death (Chan, 2013, Vogel, 2014). If the mother dies during giving birth but the infant survives, the consequential shortage of nutritional support in the form of breastfeeding leaves the baby vulnerable to malnutrition, which can itself be fatal or may increase the risk of disease or death from infection (Ronsmans, 2010 & Braitstein et al, 2013). Using data from 18,189 live births to 5119 mothers in the Butajira Health and Demographic Surveillance System (HDSS) site in Ethiopia, Corrina (2015) found that when a woman experienced a maternal death, her infant was much more likely to die, and approximately 81% of infants of the died mothers also died. Butajira is one of the 770 Woredas (mentioned above) in Ethiopia.

The death of mothers and their newborns is directly related to a failure to give effective maternal health care (Paul & Judith, 2007). The majority of maternal and infant deaths could be avoided if all women had access to the interventions for treating pregnancy and birth complications, especially emergency obstetric care (Wagstaff & Claeson, 2004). This study also attempts to investigate the effect of maternal health factors on infant mortality. I attempted to review the findings of several researchers studied on the determinants of infant mortality in different perspectives as summarized below.

2.3.1 Proximate determinants

Maternal factors

According to the Mosley & Chen (1984) framework, proximate determinants of infant mortality include maternal factors, environmental contaminations, nutritional deficiency, injuries, and personal illness controls. The focus of this study is on maternal factors, specifically maternal health factors. The maternal health factors considered in this study include antenatal care (ANC), delivery by cesarean section, maternal vaccination, family planning, place of delivery (DC), and postnatal care (PNC). Maternal vaccination represents the number of tetanus injections before birth and PNC represents health care given to women within two days after delivery, and delivery care is a health care given to women while giving birth.

Giving special attention to pregnant women in the public health services was not begun until the 1930`s, latter; it was initially introduced in the United Kingdom and Northern Ireland states. It was decided that every pregnant woman should get a regular check-up as an integral part of

maternity care. This is one of the important components of maternal health which is now called antenatal care. Antenatal care is the routine health control of presumed healthy pregnant women without symptoms, to diagnose diseases or complicating obstetric conditions without symptoms and to provide information about lifestyle, pregnancy, and delivery. Good care before, during and after childbirth can save the lives of both mothers and infants (WHO, 2019). Evidence reveal that effective use of ANC, DC, and PNC enhances the survival and health of women and their babies (UNICEF, 2006).

Effective ANC allows timely detection and early treatment of preventable diseases which reduce infant mortality. Early screening and treatment of high blood pressure, to prevent eclampsia, has been found to greatly reduce both mother and infant mortality (McCaw-Binns et al, 2004). Moreover, improved pregnancy outcomes have been registered through the screening and treatment of anemia (Reynolds, Wong & Tucker, 2006). The relevance of ANC, thus, lies in its role for early detection of pregnancy-related complications; and it provides information on danger signs and the mechanisms to prevent the associated risks (Yuster, 1995). Specific services of ANC include prevention and treatment of malaria, tetanus immunization, management of anemia during pregnancy, and treatment of sexually transmitted infections. The use of these services is important for the deaths of mothers and their infants; moreover, ANC relevant for HIV prevention and care including prevention of mother to child transmission of HIV (Br Med Bull, 2003). It is well known that WHO previously recommended four antenatal visits for safe pregnancies. But, WHO now recommends a minimum of eight visits to enhance the quality of neonatal outcomes and to provide effective experience for clients (WHO, 2016). Antenatal care has an indirect impact on decreasing maternal mortality as it motivates mothers to deliver in a health facility with the support of skilled birth attendants (Peter, 2009). Several studies suggest that women receiving antenatal health care during pregnancy have healthier birth outcomes and have fewer infant deaths (Gajate-Garrido 2013; Habibov and Fan 2011, Maitra 2004).

Much of the famous literature has concentrated on identifying the relationship between antenatal care and infant mortality in developed countries (Kutinova 2006, Noonan et al.2013). Though, the question of whether a relationship exists between these two important factors hasn`t been addressed in less developed countries where only recent research has started to emerge (Awiti 2014). In Sub-Saharan Africa, about 80% of pregnant women attended at least one antenatal care visit and 52% of pregnant women received the recommended number of four

antenatal care visits in 2016 (Tesfalidet, 2019). However, according to the EDHS (2016), the utilization of antenatal care, delivery care, and postnatal care services in Ethiopia are all among the lowest in sub-Saharan Africa. The report shows that only 62% of women in age of 15-49 years receive antenatal care from a skilled provider, i.e., from a doctor, nurse, midwife, health officer, or health extension worker. And, 32% of women attended four or more ANC visits. Only 26% of births take place in a health facility whereas 74% of births occur at home without assistance from health professionals. The report also reveals that only 17% of women age 15-49 receive a postnatal check within two days of delivery, while 81% did not have a postnatal check within 41 days of delivery. 87% of newborns don´t receive a postnatal check within two days of birth.

Skilled birth attendance encompasses not only the presence of professionals (midwives, doctors, nurses, etc) during delivery but also an enabling environment where the equipment, drugs, and other supplies required for effective and efficient management of obstetric complications are available (Bell, Curtis & Alayon, 2003). Skilled birth attendants (SBA) are trained to recognize the signs of complications early enough to intervene and manage the situation or make quick referrals to higher levels of care. Available evidence suggests that the presence of SBAs during delivery dramatically reduces maternal and infant mortality mortalities (Reynolds et al, 2004; Kruk et al, 2007; Mpembeni et al, 2007). In countries like Sweden and UK significant numbers of deliveries take place at home by trained midwives with physicians attending only women with complications or who are at high risk; on the other hand in developing countries like Ethiopia most women deliver at home and if the woman has complications it may not be detected and she may or may not be taken to a health facility (Gynaecol Obstet, 2005).

Another maternal health factor is maternal vaccination. To improve maternal immunity and the transplacental transfer of antibodies to the fetus, immunization of pregnant women is an effective strategy for the prevention of neonatal tetanus (Moss, 2002). According to Moss, the average worldwide coverage of maternal immunization, measured by the indicator for two doses of tetanus toxoid ‘‘TT2’’, is only 65%, but it is highly recommended to use it in pregnant women and women of childbearing age, and between 300,000 and 400,000 cases of neonatal tetanus occur each year, resulting in approximately 248,000 deaths in 1997 (WHO, 1999). Neonatal tetanus accounts for approximately 14% of the global neonatal deaths, responsible for 25% in some African countries including Ethiopia (WHO, 2001). The 2016 EDHS report

reveals that more than half of women's last births in Ethiopia were not protected against neonatal tetanus which is very far from the global average.

Delivery by Cesarean section is also an important maternal health indicator in the study. Cesarean birth is the surgical delivery of a baby through a cut made in the mother's abdomen and uterus. Health care providers use it when they believe it's safer for the mother, the baby, or both. Cesarean section is the commonest obstetric operative procedure all over the world. If used properly, cesarean sections can enhance infant and/or maternal outcomes. But, If not used properly, the potential harm may exceed its potential benefit (Abebe, 2016). It's estimated by the World Health Organization (WHO) that 10 to 15 % of all births medically require a cesarean section (WHO, 2018). Cesarean section delivery is stagnant in Ethiopia. Both the 2011 and 2016 Ethiopian demographic and health survey reports show that only 2 % of the women had undergone cesarean section in Ethiopia which is very far from the WHO global minimum threshold of 10 %. Maternal education plays a vital role for caesarean deliveries in Ethiopia (2016 EDHS). However, the maternal literacy rate is very low in Ethiopia (UNESCO, 2015). This means that the majority of women who are at their childbearing age aren't educated. These less-educated women may not have the necessary awareness about the use and importance of delivery by cesarean section, and they can't afford the costs associated with health care services. Moreover, being 85% of the population live in the rural part of the country, this aggravates this poor access to delivery by cesarean section and can leave pregnancy and birth complications untreated resulting in the death of infants in the country.

A large body of literature shows that other maternal factors such as maternal age at birth, parity, and birth interval have a potential relationship with infant mortality, especially low-income countries where maternal care is less during pregnancy and delivery. According to Chidambaram V.C. et al. (1985), if an infant is born within two years of another child, then both children have a very high risk of dying. Soest A.V. (2018) studied the relationships between infant mortality, birth spacing, and fertility in Bangladesh, and found that higher mortality rates are associated with shorter birth intervals in the study area. They used a dynamic panel data approach to analyze the causal effects of infant mortality on birth intervals. Moreover they identified the causal effects of birth intervals on infant mortality in rural Bangladesh.

The significant effect of maternal age at first birth on infant mortality has been determined by several researchers. These studies suggest that, in most cases, women below the age of 20 are biological immaturity and unable to care for their children and these women are economic

instability and they have less experience of motherhood which all contribute to high infant mortality. The age of women at first birth is found to be related to high infant deaths (Patel R.M., 2000).

For the particular case of Ethiopia, numerous studies have been documented on the determinants of infant mortality, many of which used the Ethiopian Demographic health surveys as the main sources of information. Using the 2005 EDHS, Kumar and Gemechis (2010) investigated that the highest infant mortality risk is associated with children of less than two years of a birth interval with previous child (15 %) and the lowest risk was recorded for the children whose birth interval was 4+ years (4.2 %). They also found that higher parental education is highly correlated to the low risk of infant mortality as compared to mothers and fathers with less educational level. The findings suggest that birth order and place of residence are also important determinants of infant mortality in Ethiopia.

Nutrition deficiency

Furthermore, a study by Agha (2000) found that reduced food availability could significantly increase the rate of maternal and infant mortality rates in Pakistan using household-level data for the years 1993-1994. Nutrient deficiency is known to be a proximate determinant factor for maternal and infant mortality. Pregnant women in the region could feed their infants with less quality of breast milk and the women themselves could be undernourished which results in low birth weight. Using piecewise linear regression, Abrams (1995) examined the associations between maternal weight gain per trimester and maternal characteristics and pregnancy outcomes using maternal weight data measured prospectively from all sending between 1980-1990 at the University of California, San Francisco. The study suggests that maternal weight gain per trimester is correlated with maternal characteristics and pregnancy outcomes.

In countries like Ethiopia, malnourished women are more likely to have short stature in adulthood and they have high rates of adverse pregnancy outcomes such as prenatal mortality and prematurity (Barros FC., et al, 1987). Studies suggest that shorter maternal height and greater newborn weight are contributing to increased delivery complications and result in maternal or fetal mortality and morbidity. The findings show a similar association for women residing in the developed world and less developed countries. To examine the association between maternal height and delivery outcome, Alka et al (2016) considered random samples of 125 full-term primigravida women without any obstetric and medical complications who

were admitted to Rama Medical College, Hapur, Uttar Pradesh. Out of 44 short-statured women (height ≤145 cm), 41 (93.18%) had the cesarean section, and 2 (4.55%) women were delivered vaginally. The estimated fetal weight in the control group was 2845 g while that in the study group was 2928 g. The study confirms that short-statured females with larger baby sizes have a higher incidence of delivery by cesarean.

Environmental contamination

Using the survival analysis framework, Mutunga (2007) identified the effect of environmental characteristics which include access to safe drinking water and sanitation facilities on infant mortality through poor maternal health using the Kenyan Demographic and Health Survey data. The study illustrates infants from households with safe drinking water and adequate sanitation facilities were less likely to die as compared with those with unsafe drinking water and inadequate sanitation facilities.

Desta (2011) identified that toilet facility, source of drink water, and floor material do not have a consistent effect on infant mortality in Ethiopia using the 2000 and 2005 Ethiopian Demographic and Health Surveys. The study also shows that the effect of the smaller birth intervals is associated with higher infant mortality in both surveys due to biological and socioeconomic factors. This is consistent with Kombo and Ginneken (2009) which shows that multiple births are highly correlated with high infant mortality than single births in Zimbabwe.

2.3.2 Socioeconomic determinants

Many studies illustrate that socioeconomic status plays a vital role in reducing infant deaths in different regions of the world as improved socioeconomic status can lead to access to use maternal health facilities and better infant care, and it can also cause other factors to change, such as environmental contamination, sanitation, and nutrient deficiency. Due to less improvements in socioeconomic and health development in third world countries, the high rates of infant mortality attract the attention of many researches and lead to the availability of abundant literature in the regions. In the process, several studies confirmed that education, especially maternal education, continues to be the key factor for the loose of infants at an early age in the developing world. This is directly linked with the very low coverage of women education in these regions even during the 21st century. Mutunga (2007), Caldwell and McDonald (1982), Charmarbwala et al (2004), Pandey et al (1998), and Agha (2000) identified the role of maternal education on infant mortality in different developing countries.

Results obtained from the analysis of the 1986 Ondo State Demographic and Health data indicate that infant mortality rates are higher for the infant of less-educated mothers than more educated ones in Nigeria (Adetunji J.A., 1995). Caldwell and McDonald conducted a study on maternal education and infant survival in Nigeria in 1982 and found a strong association between infant survival and maternal education in the country. Using data from the World Fertility Survey in ten developing countries, the researchers found that the huge declines in infant mortality in developing countries including Nigeria before 1970s was due to maternal education, in addition to technological and economic improvements during the period. The study also reveals that the role of maternal education, maybe greater than the combined effect of income and access to maternal and infant health facilities and the inequality in infant mortality between the place of residences didn´t vary when maternal education was held constant which shows how sensitive is infant mortality to maternal education in the case of less developed countries. Moreover, Agha (2000) found that mothers and fathers' education and Household income significantly increased infant mortality in Pakistan using household-level data. On the contrary, Kombo and Ginneken (2009) found that maternal education has no important effect on infant mortality in Zimbabwe using the 2005 Zimbabwean DHS.

Using instrumental variable estimation and data across countries and over time, Pritchett and Summers (1996) confirmed that wealthier nations are healthier using infant mortality as a measure of a country´s health performance. Their finding indicates that both infant mortality

rates and life expectancy sharply decline as income increases, especially for the case of the poorest countries. According to this study, there are three reasons for such a wealth-health relationship. One explanation is that high income leads to better health, healthy people are more productive and get more income (reverse causality) and there are some factors that are associated with both health and wealth at the same time. Poor mothers are at high risk of developing pregnancy-related complications. Almost all maternal deaths during giving birth that occurs in low and middle-income countries are mainly among the poorest of the poor (WHO, 2005).

Moreover, Nishiyama (2011) identified the relationship between infant mortality on GDP per capita using instrumental variable estimations and panel data from 83 developing countries over 40 years. Nyasha (2017) also used the infant mortality rate as a proxy to measure the level of poverty and economic growth in Ethiopia. Using this variable, the researcher investigated the causal relationship between poverty reduction and economic growth in Ethiopia during the period from 1970 to 2016.

2.3.3 Biological determinants

Studies show that higher infant mortality is observed among mothers who are younger at first birth (less than 20 years) (Bell et al., 2003). One reason for this could be the fact that younger women are not physically matured which may have a negative effects during pregnancy and delivery. According to Rush (2000), obstructed labor is a major contributor to maternal deaths in developing countries and can cause complications such as obstetric fistula. The finding shows that young women and women giving birth for the first time are at higher risk of obstructed labor. Young women are also economically dependent which makes them less use of maternal health facilities. There are inconsistent findings though in the relationship between parity and health-seeking behaviors. Parity indicates the number of pregnancies reaching viable gestational age (including live births and stillbirths). Due to greater confidence and cumulative experience, high parity women are the least likely to seek maternity care services (Celik, 2000).

Studies suggest that birth intervals are linked with poor maternal and child health outcomes. World Health Organization defines birth interval as the time from live birth to a successive pregnancy and the recommended period is at least 24 months (WHO, 2007). Short birth intervals defined as those less than 2 years have implications on maternal and child health

(Perin, 2015), and long birth intervals defined as those above 5 years have also undesired effects on maternal and child health (Conde, 2006). Adequate birth intervals on the other hand help women recover from macro-and micronutrient depletion which occurs during pregnancy and lactation (Conde, 2012).

3 Data and Methods

3.1 Data

The Demographic and Health Surveys

The Demographic and Health Survey (DHS) program is the world's largest survey, and it is a reliable and commonly used health survey all over the world. The survey gathers all relevant data on human health, such as maternal and childhood and health service indicators. According to WHO (2000), the program carried out more than 104 analogous surveys in 62 developing countries including Ethiopia, and the United States Agency for International Development has provided most of the funds needed to conduct the surveys.

The Ethiopian Demographic and Health Surveys

Ethiopia conducted the first Demographic and Health Survey in 2000 and continued to carry out the next surveys in each five years. As part of DHS, the 4th Ethiopian Demographic Health Survey (EDHS) has been conducted in 2016. The data used in this study come from the most recent 2016 EDHS. The 2016 EDHS is a cross-sectional study that has been conducted from January 18, 2016, to June 27, 2016 throughout the country. The survey used a two-stage cluster sampling strategy. A total of 645 clusters were randomly selected proportional to the household size from the sampling strata in the first stage and 28 households were selected in each cluster using systematic random sampling in the second stage.

According to the 2016 Ethiopian Central Statistical Agency (CSA) report, a total of 18,008 households were selected for the sample. Among the selected households, 17,067 households were occupied during the interview period. Then, a representative sample of 16, 650 households were interviewed among the occupied households with a response rate of 98% from the total of 18,008 households selected in the survey. 16, 583 eligible women were identified from the 16,650 interviewed households. Finally, samples of 15,683 women of reproductive age (15–49 years) were completed.

The unit of analysis for this study is women who had a live birth and have a child of age less than 1 year in the five years preceding the survey regardless of the survival status of the infant. During the time of the survey, if a woman had more than one live birth in the past five years preceding the survey, only the most recent live birth was considered. The study considered 10,510 live births of which 495 died before reaching the age of 1 year.

Since samples weren't taken proportional to size across regions and between urban and rural areas during data collection in the survey, I performed sample weighting before conducting data analysis to compensate for the unequal probability of selection between the strata that has been geographically defined as well as for non-response. Sample weighting was performed in SPSS using women's sample weight as a weighting variable. The size and national representativeness of the data validate the analysis in this study.

3.2 The Approach

Descriptive statistics are used to explain the prevalence of infant mortality in the study area, and bivariate analysis is followed and finally multivariate analysis is used. For bivariate analysis, Chi-square is employed to see the association between infant mortality and maternal health indicators. For multivariate analysis, multivariate logistic regression is used to identify the determinants of infant mortality in the study area. Moreover, a hierarchical model is used to look at regional variation in maternal health behaviors among the different regions of the country.

Variables used in the analysis

Several researchers have linked socioeconomic and other health-related variables with infant mortality using a different analytical framework. However, as described in figure 2.5 above, the association of causal factors of infant mortality which was developed by Mosley–Chen is used as the most widely used framework in the study of infant mortality, specifically to developing countries. The focus of the current study is to identify the association between maternal health factors and infant mortality in Ethiopia using the Mosley–Chen framework.

Outcome variable

Based on Mosley & Chen (1984), mortality takes as an outcome variable since deaths are unusual and rare events in most of the research in social science and it is easily calculated. Similarly, I took infant death as a dependent variable in this analysis. Hence, the outcome variable in this study is infant death, which is the death of a live-born infant in the first year of life and it has two categories, death, and no death. With the dichotomous outcome variable, the multivariate logistic regression is a suitable statistical model to identify the determinants of infant mortality linked to maternal health factors in Ethiopia.

Explanatory variables

It is well documented about the socioeconomic and proximate determinants of infant mortality both in social and health sciences. But, this study considers only the proximate factors which are centered on maternal health indicators of infant mortality in Ethiopia. These variables include use of antenatal care, delivery by cesarean section, maternal vaccination (number of tetanus injections before birth), family planning, place of delivery, and respondent's health checked before discharge (PNC). Other determinants of infant mortality, namely, region, place of residence, mother's education, mother's work status, mother's current age, birth order, and mother's wealth index are controlled variables in this study. Descriptions of the variables considered in the study are given in table 3.1 below.

Table 3.1: *Operational definition, categorization, and coding of variables*

Variable	Description of the variable
Explanatory variables considered	
Antenatal care visit	Antenatal service received by the mother (0 = No and 1 = Yes)
Delivery by cesarean section	Delivery by cesarean section (0 = no cesarean delivery and 1 = cesarean delivery)
Maternal vaccination	Number of tetanus injections before birth (0 = No injection and 1 = at least one tetanus injection before birth)
Family planning	Family planning used by the mother (0 = No and 1 = Yes)
Place of delivery	Place of delivery (0 = delivered at home, 1 = delivered at health facilities)
Postnatal care	Postnatal check-up visits (0 = No, 1 = yes)
Control variables	
Region	1= Tigray, 2= Afar, 3= Amhara, 4= Oromia, 5= Somali, 6= Benishangul, 7= SNNPR, 8= Gambela, 9= Harari, 10= Addis Adaba, 11= Dire Dawa
Place of residence	Place of residence (0 = Rural, 1 = Urban)
Mother's education	Maternal formal years of schooling (0 = No formal school education, 1 = Primary education i.e., up to class eight, 2 = Secondary and higher education i.e., above class eight)
Mother's work status	Mother's occupational status (0 = Not working, 1 = not working)
Mother`s age at birth	Maternal age at birth (1 = less than 20 years, 2 = 20-29 years, 3= 30-39 years & 4=40-49)
Birth order	Birth order (1= 1st birth, 2= 2nd -3rd birth, 3=4th-6th & 4=7+)
Mother's wealth index	Wealth quintiles (0=lowest, 1= second, 2= middle, 3=fourth, 4= highest)

Model

Multivariate Logistic Regressions

The significance of maternal health behaviors on infant mortality is assessed using multivariate logistic regression. Logistic regression analysis is a widely used and popular analysis that is analogous to linear regression analysis exception is that the outcome is dichotomous; in this case, the death of infant which is categorized as death occurred/no death occurred. Independent variables can assume any type such as categorical, continuous, and dichotomy variables. Logistic regression ranks the independent variables according to relative importance. The impact of explanatory variables is explained in the terms of odds ratio using maximum likelihood estimation after transforming the predicted variable into the logit variable. In the

current study, infant mortality is analyzed by using a multivariate logistic regression model and the main aim of this study is to identify the role of maternal characteristics in infant mortality in the case of Ethiopia. The model can be described in general as:

$$\text{Logit}(p) = \log (P/1\text{-}P) = \beta_0 + \beta_1 X_1 + \beta_1 X_2 + \beta_3 X_3 + ... \beta_k X_k$$

Where: β_0 is a constant number and βk are coefficients

X_k is Independent variables

P is the outcome (dependent variable)

The model can also be specified as:

$$\text{Logit } (P) = \beta_o + \beta_1 * \text{antenatal care} + \beta_2 * \text{delivery by caesarean section} + \beta_3 * \text{vaccination} + \beta 4 * \text{family planning} + \beta 5 * \text{place of delivery} + \beta 6 * \text{postnatal care.}$$

Hierarchical logistic regression modeling is also used to identify the regional variations in infant mortality associated with maternal health indicators. In this research, the hierarchical logistic regression model has a binary outcome, infant death, and no infant death.

A hierarchical problem concerns a population with an ordered structure. A sample from such a population can be described as a multistage sample. This study uses the 2016 EDHS data which has been collected by using a two stage cluster sampling; in such samples, the individual observations are not completely independent.

Infants in the same geographical region tend to be similar to each other, because of selection processes (for instance, mothers of the infants with the same ethnic group are expected to be found in the same region. As a result, the average correlation (expressed in the so-called intraclass correlation) between variables measured on mothers from the same region will be higher than the average correlation between variables measured on mothers from different regions. Standard statistical tests bend heavily on the assumption of independence of the observations. If this assumption is violated (and in hierarchical data this is almost always the case) the estimates of the standard errors of conventional statistical tests are much too small, and this results in many spuriously ‘significant’ results.

The effect is generally not negligible, as small dependencies in combination with large group sizes still result in large biases in the standard errors. The strong biases that may be the effect of violation of the assumption of independent observations made in standard statistical tests

have been known for a long time (Walsh, 1947) and are still a very important assumption to check in statistical analyses (Stevens, 2009).

The problem of dependencies between individual observations also occurs in survey research, if the sample is not taken at random but cluster sampling from geographical areas is used instead. For similar reasons as in the EDHS data, respondents from the same geographical area will be more similar to each other than are respondents from different geographical areas. This leads again to estimates for standard errors that are too small and produce spurious 'significant' results.

In hierarchical research, the structure of data in the population is hierarchical, and a sample from such a population can be viewed as a multistage cluster sample. This clustering sampling scheme often introduces hierarchical dependency among the observations that can have implications for model parameter estimates. In this study the basic data structure of the two-level logistic regression is a collection of N groups (regions) and within-group j ($j = 1,2, \dots, N$), a random sample n_j of level-one units (infants). The response variable, let $Y_{ij} = 1$ if the i^{th} infant in j^{th} region die and $Y_{ij} = 0$ otherwise; with probabilities, $P_{ij} = P(y_{ij} = 1|X_{ij}, u_j)$, is the probability of infant death for infant i in region j; where u_j is a random cluster effect and often assumed to be $N(0, \sigma_u^2)$. Let P_{ij} be modeled using a logit link function. The two-level hierarchical model is given by:

$$\text{logit}(p_{ij}) = \log\left(\frac{p_{ij}}{1 - p_{ij}}\right) = \beta_{oj} + \sum_{l=1}^{k} \beta_{lj} x_{lij}\,; \qquad l = 1,2, \dots, k$$

Where $\beta_{0j} = \beta_0 + U_{0j}, \beta_{1j} = \beta_1 + U_{1j}, \dots, \beta_{kj} = \beta_k + U_{kj}$

The level-two model can be rewritten as:

$$\text{logit}(p_{ij}) = \log\left(\frac{p_{ij}}{1 - p_{ij}}\right) = \beta_o + \sum_{l=1}^{k} \beta_l x_{lij} + U_{oj} + \sum_{l=1}^{k} U_{lj} x_{lij}$$

Where $X_{ij} = (X_{1ij}, X_{2ij}, \dots, X_{kij})$ represent the first and the second level covariates, $\beta = (\beta_0, \beta_1, \dots, \beta_k)$ are regression coefficients, $U_{0j}, U_{1j}, \dots, U_{kj}$ are the random effect of the model parameter at level two. It assumed that the $U_{0j}, U_{1j}, \dots, U_{kj}$ follow a normal distribution with mean zero and variance δ_u^2. If no predictor is considered in the model, it is in its simplest form, $\text{Logit}(P_{ij}) = \beta_{oj} = \beta_o + U_{0j}$, where β_o is the population average of the transformed probabilities and U_{oj} is the random deviation from this average for group j.

4 Empirical Analysis

4.1 Results

4.1.1 Univariate Analysis

The analysis of this study is a retrospective study based on data consisting of 10,510 live births, of which 504 (4.8 % of the total live births) died before celebrating their first birthday. The overall prevalence of infant mortality rate is 48 per 1,000 live births in Ethiopia, and this result is consistent with the result from the 2016 EDHS report. The deaths of 504 infants account for approximately 88% of all the deaths of children under the age of five years in the survey.

Results of the univariate analysis showed that mothers of the infants utilized low maternal health care services in the current study. Proportions of use of antenatal care, delivery by cesarean section, maternal vaccination, family planning, place of delivery and PNC are 50.4%, 2.9%, 69.7%, 26%, 33%, and 12.8% respectively (see table 4.1). These poor maternal health indicators seem to be the result of low socioeconomic status of mothers considered in the study such as age at birth, work status, education, wealth, and place of residence of mothers of the infants.

Very low proportions of mothers delivered by cesarean section (2.9%), but WHO recommendation ranges 10-15%. This low delivery by cesarean section indicates that many of the complications that might be occurred during pregnancy and birth in the five years preceding the survey left untreated in the country. This result is consistent with the 2016 EDHS report. This low delivery by cesarean is stagnant as it was 2% both in the 2011 and 2016 EDHS. Similarly, delivery by cesarean is low in this study though about 33% of all the deliveries took place at health facilities implying the scarcity of resources at health institutions to treat pregnancy and birth complications in the country.

About 87.2 % of mothers of the infants considered in this study didn't use postpartum care which means utilization of postnatal care among mothers of the infants was only 12.8 %. A higher proportion of mothers of the infants live in the rural parts of the country, 81.3%. Mothers

living in urban areas have limited access to health facilities as many heath institutions are located in urban areas. Not only the low availability and accessibility of health facilities but also the distance from health institutions can results in poor birth outcomes in rural areas, especially, when birth complications occur and referral to higher care is required. Mostly, women living in rural areas have lower socioeconomic status and hence can't afford the costs of health care services. Due to several reasons, mothers living in rural parts of the country have low access to maternal health facilities which in turn leads them to experience higher infant deaths.

***Table 4.1**: Results of univariate analysis, 2016 EDHS*

Variables	Category	Number of live births	Percentage
Study variables			
Antenatal care visit	No	5216	49.6
	Yes	5294	50.4
Delivery by cesarean	No	10206	97.1
	Yes	304	2.9
Maternal vaccination	No	3189	30.3
	Yes	7321	69.7
Family planning	No	7774	74
	Yes	2736	26
Place of delivery	Home	7039	67
	Health facility	3471	33
Postnatal care	No	1351	87.2
	Yes	1343	12.8
Control variables			
Region	Tigray	1023	9.7
	Afar	1034	9.8
	Amhara	971	9.2
	Oromia	1563	14.9
	Somali	1493	14.2
	Benishangul	862	8.2
	SNNPR	1262	12
	Gambela	702	6.7
	Harari	599	5.7
	Addis Adaba	460	4.4
	Dire Dawa	541	5.1
Place of residence	Urban	1967	17.7
	Rural	8543	81.3
Mother's work status	No	7585	72.2
	Yes	2925	27.8
Mother`s age at birth	<20	6488	61.7
	20-29	3851	36.6
	30-39	170	1.6
	40-49	1	0.0
Birth order	1 birth	2143	20.4
	2-3 birth	3306	31.5
	4-6 birth	3333	31.7

	7+	1728	16.4
Mother's wealth index	Poorest	3927	37.4
	Poorer	1762	16.8
	Middle	1448	13.8
	Richer	1291	12.3
	Richest	2082	19.8

The majority of the mothers have no education, 64.1%. As can be seen from the literature, maternal education is the most determinant factor for both use and access to maternal health care services and infant mortality. The vast number of mothers of the infants is illiterate, 64.1%. Together with mothers with elementary education, illiterate mothers constitute 89.4% and only 10.6% of the mothers considered in the study have secondary and higher education (see figure 4.1). This very low level of mother's education indicates the government's weakness to empower women in the country. Works of literature reveal that empowering women through education has benefits not only to reduce infant deaths but also to the growth and development of the whole population of the country.

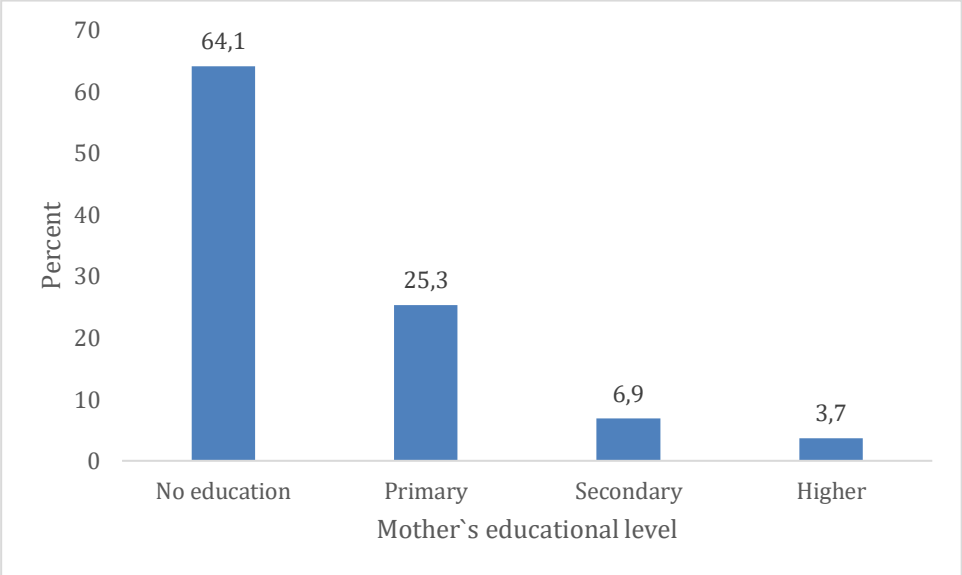

Figure 4.1: *Mothers` educational level*

Approximately 88.3% of the infants have mothers residing in rural parts, and the remaining 11.7% reside in the urban areas of Ethiopia in the study. A higher proportion of the infants involved in the survey have jobless mothers (72.2%) at the time of the interview while only 27.8% of the mothers have a job. Jobless mothers experienced more infant death than mothers having a job. One possible reason for this higher infant death can be due to the case that jobless mothers depend on their husbands/partners to decide on the use of maternal health care services. They have also less access to maternal health care services as compared to mothers having a job. The majority of the mothers (62%) gave birth before they reach the age of 20 years. This means that a considerable portion of mothers gave birth before physical and biological maturity.

Immature mothers have less capacity to care and feed their newborns which lowers the survival of their infants. A considerable proportion of the infants have poor mothers, 45%. Poor mothers can't afford the costs related to pregnancy and birth by themselves. And hence, the use of these services depends on the decision of husbands/partners which lowers the probability of use of maternal health care.

4.1.2 Bivariate Analysis

Infant death was higher for those mothers who didn't attend antenatal visits (5.1%) that those who used the service (4.5%). The variation in infant deaths linked to antenatal visits is due to the reason that mothers who received antenatal care could detect the possible problems that might occur during birth. This could allow them to treat the problems timely and could avoid infant deaths. Mothers could also get the relevant information about maternal health and infant care from health provides during their antenatal visits.

Death of infants differs among the geographical regions of Ethiopia. It is highest in the Somali regional state (91) and lowest in Addis Ababa (13). The lower infant deaths in Addis Ababa are related to the accessibility of health facilities in the region which is the capital city of Ethiopia. Each year, many health providers fly to the capital city seeking for better living conditions. There are many private health institutions in the capital city that increases health care services in the region. Mostly, mothers living in the capital city have higher socioeconomic status and hence, they have better capability and awareness for maternal health.

More than 88% of infant deaths (444 deaths out of 504 total deaths) occur in rural part of the country. Mothers living in the rural areas are one of the disadvantaged groups in the country who have less living standards and face different problems related to maternity. Most of the mothers residing in rural areas have a lower socioeconomic status which limits them to spend on their health. Moreover, many of the health institutions and skilled health providers are located in the urban parts of the country. As a result of these and other reasons, mothers in rural areas face maternal health problems which can lead to poor birth outcomes in the area.

The proportion of infant death is higher for infants whose mothers delivered at home (5.2%) as compared to those delivered at health facilities (3.9%). This could be due to the reason that a considerable number of women delivered at home didn`t get assistance from health providers for their pregnancy and birth complications leading to maternal and/or infant deaths. This

reveals the country's poor performance in response to birth complications due to shortage of skilled manpower and medical resources that can serve for mothers during pregnancy and birth in the country. There can be several reasons for delivery at home in the country. One possible reason is that many mothers don`t attend antenatal visits, and hence they couldn`t get the necessary knowledge about maternal health and the possible complication that may arise during birth. As mentioned above, 88.3% of infants have mothers residing in rural parts. Availability of health facilities is very low in rural areas and transportation service from rural to urban is also poor in the country. And hence, mothers face serious maternal health problems due to accessibility and availability of maternal health care, especially in the rural parts of the country.

A higher proportion of infant death is also observed for mothers of infants who don`t use family planning in the survey (401 infant deaths out of 504 total infant deaths). Only 26 % of the mothers considered in the study used family planning implying that the remaining portion of mothers didn`t use family planning, and hence they didn`t limit and spaced their children which can cause pregnancy and birth complications.

Table 4.2: *Results of the bivariate analysis, 2016 EDHS*

Variables	Category	status of an infant		Chi-square
		Number of deaths (%)	Number of no deaths (%)	
Study variables				
Antenatal care visit	No	265 (5.1)	4951 (94.9)	0.000*
	Yes	239 (4.5)	5055 (95.5)	
Delivery by cesarean	No	494 (4.8)	9712 (95.2)	0.000*
	Yes	10 (3.3)	294 (96.7)	
Maternal vaccination	No	132 (4.1)	3057 (95.9)	0.000*
	Yes	372 (5.1)	6949 (94.9)	
Family planning	No	401 (5.2)	7373 (94.8)	0.000*
	Yes	103 (3.8)	2633 (96.2)	
Place of delivery	Home	368 (5.2)	6671 (94.8)	0.000*
	Health facility	136 (3.9)	3335 (96.1)	
Postnatal care	No	34 (2.5)	1317 (97.5)	0.000*
	Yes	35 (2.6)	1308 (97.4)	
Control variables				
Region	Tigray	31 (3)	992 (97)	0.000*
	Afar	62 (6)	972 (94)	
	Amhara	43 (4.4)	928 (95.6)	
	Oromia	69 (4.4)	1494 (95.6)	
	Somali	91 (6.1)	1402 (93.9)	
	Benishangul	47 (5.5)	815 (94.5)	
	SNNPR	56 (4.4)	1206 (95.6)	
	Gambela	32 (4.6)	670 (95.4)	
	Harari	35 (5.8)	564 (94.2)	
	Addis Adaba	13 (2.8)	447 (97.2)	
	Dire Dawa	25 (4.6)	516 (95.4)	
Place of residence	Urban	60 (3.1)	1907 (96.9)	0.000*
	Rural	444 (5.2)	8099 (94.8)	
Mother's education	No education	349 (5.2)	6387 (94.8)	0.000*
	Primary	117 (4.4)	2538 (95.6)	
	Secondary	32 (4.4)	697 (95.6)	
	Higher	6 (1.5)	384 (98.5)	
Mother's work status	No	366 (4.8)	7219 (95.2)	0.000*
	Yes	138 (4.7)	2787 (95.3)	
Mother`s age at birth	<20	331 (5.1)	6157 (94.9)	0.000*
	20-29	164 (4.3)	3687 (95.7)	
	30-39	9 (5.3)	161 (94.7)	
	40-49	0 (0)	1 (100)	
Birth order	1 birth	112 (5.2)	2031 (94.8)	0.000*
	2-3 birth	144 (4.4)	3162 (95.6)	
	4-6 birth	151 (4.5)	3182 (95.5)	
	7+	97 (5.6)	1631 (94.4)	
Mother's wealth index	Poorest	221 (5.6)	3706 (94.4)	0.000*
	Poorer	92 (5.2)	1670 (94.8)	
	Middle	62 (4.3)	1386 (95.7)	
	Richer	64 (5)	1227 (95)	
	Richest	65 (3.1)	2017 (96.9)	

Note: * P-value < 0.05

4.1.3 Multivariate Analysis

Results of Multivariate Logistic Regression Model

Before analyzing data using a statistical model, it is highly recommended to check for model adequacies. There are different methods of assessing the overall fit of the logistic regression model. Omnibus test of model coefficients, Pearson's Chi-square test, the likelihood ratio tests (LRT), Hosmer and Lemeshow Goodness of fit test and the Wald tests are the most commonly used measures of goodness of fit for categorical data (Hosmer and Lemeshow, 1989). The result of omnibus tests of models coefficients having a chi-square value of 19,656 with 7 degrees of freedom is highly significant at a 5% level of significance. This indicates that the logistic regression model is a good fit mode in this study (see table 7.1 in the appendix).

Then, multivariate logistic regression has been fitted based on the chi-square test results of bivariate analysis. The main problem with the bi-variate approach is that it ignores the possibility that a collection of variables, each of which could be weakly associated with the outcome, can become an important predictor of the outcome when taken together (Hosmer and Lemeshow, 1989). As a result, a multivariate logistic regression approach that takes into account the drawback mentioned by the bi-variant technique is employed in the next analysis.

All maternal health characteristics, namely, use of antenatal care, delivery by cesarean section, maternal vaccination, family planning, place of delivery, and use of postnatal care are considered in the multivariate analysis to examine their role on infant mortality when all these factors are considered together. According to the 2016 Ethiopian Demographic and Health survey, five of the six maternal health factors considered in the study, namely, use of antenatal care, cesarean delivery, maternal vaccination, family planning, and use of postnatal care have a significant role on infant mortality in Ethiopia.

The results of multivariate logistic regression revealed that infants whose mothers didn`t attend antenatal visits, delivered without cesarean section, didn`t vaccinate and didn`t receive postnatal care were more likely to die in the study. The odds ratios of caesarean delivery indicate that infants of the mothers who didn`t deliver by cesarean section are more likely to die as compared to those infants whose mother delivered by cesarean section in the study.

Table 4.3: *Estimates of the parameters from the multivariate logistic regression, 2016 EDHS*

Infant mortality	Category	β	Sig.	exp (β)
Antenatal care	No	0.22	.000*	1.25
	Yes (ref)			
Delivery by cesarean section	No	1.22	.000*	3.38
	Yes (ref)			
Maternal vaccination use	No	1.35	.000*	1.43
	Yes (ref)			
Family planning	No	-0.73	.000*	0.48
	Yes (ref)			
Postnatal care	No	0.41	.000*	1.51
	Yes (ref)			

Note: * P-value < 0.05

To see the consistency of the importance of the predictor variables in the model, I fitted several models by incorporating several other variables that are controlled in the study (see table 4.4 below). The role of antenatal care, cesarean delivery, maternal vaccination, family planning, and postnatal care remain to be the determinants of infant mortality in all the fitted models. All the given models support that antenatal care, cesarean delivery, maternal vaccination, family planning, and postnatal care contributed to the deaths of the infants with and without the inclusion of the control variables in the study. That means, the effect of maternal health on infant mortality remains to be considered regardless of the effect of other influential socioeconomic factors that are held constant in this study to see the sole effect of maternal health factors on IMR. Place of delivery was an important factor of infant mortality when place of residence was included in the model. This indicates that the mothers residing in rural areas didn`t have equal access to delivery at health facilities as compared to mothers residing in the urban areas. More than 94 % of the mothers living in the rural areas delivered at home while less than 6 % of the mothers living in the urban areas delivered at home.

Table 4.4: *Model diagnosis, 2016 EDHS*

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
ANC	.84*	.77*	.76*	.80*	.79*	.78*	.76*	.81*
Caesarean delivery	.26*	.26*	.26*	.30*	.28*	.23*	.27*	.20*
Maternal vaccination	.68*	.68*	.69*	.70*	.70*	.67*	.68*	.63*
Family planning	2.02*	1.93*	1.95*	2.08*	2.15*	1.82*	1.94*	1.82*
PNC	.67*	.66*	.66*	.66*	.66*	.68*	.67*	.69*
Place of delivery		.61*						
Region	control							1.10*
Place of residence		control						.76*
Mother's education			control					.87*
Mother's work status				control				.93*
Mother's age at birth					control			2.10*
Birth order						control		.63*
Mother's wealth							control	1.04*
All variables together								control

Note: * P-value < 0.05

Results of hierarchical logistic regression model

I first fitted a hierarchical model with no predictor variables (an intercept-only model) which predicts the probability of infant death, and it can be considered as a parametric version of assessing heterogeneity of infant mortality among regions of the country. The variance of the random factor and the intra-region correlation in the intercept only model are used to explain regional variations in the outcome variable. The variance of the random factor (sigma-u = .1635) indicates that there is a considerable regional difference in infant mortality in Ethiopia (see table 4.5 below). The intra-region correlation of the intercept only model (rho = .0081) indicates that about 1% of the variation in infant mortality is due to region effect in the study.

Table 4.5: *Results of the hierarchical model (null model), 2016 EDHS*

Infant mortality	**Coefficient**	**Sig.**
Fixed effect		
Constant	3.01	.000*
Random effect		
sigma_u	.1635	
rho	.0081	

Note: * P-value < 0.05

The result of the random intercept model shows that the region-wise difference in infant mortality was also significant when maternal health indicators were included in this model. The intra-region correlation of the random intercept model (rho = .015) reveals that about 1.5 % of the variation in infant mortality is due to region effects associated with maternal health factors (see table 4.6 below). Family planning was found to be the only determinant of the variation in infant mortality among the regions. Except for family planning, all the other maternal health factors, namely, ANC, cesarean delivery, maternal vaccination, and PNC were not significant predictors of the variation in infant mortality across regions.

Table 4.6: *Results of hierarchical l model (random intercept model), 2016 EDHS*

Infant mortality	**Coefficient**	**Sig.**
Fixed part		
ANC	.139	.594
Delivery by cesarean section	-.3340	.746
Maternal vaccination	.0285	.921
Family planning	.8323	.004*
PNC	-.0832	.401
Random part		
sigma_u	.2236	
rho	.015	

Note: * P-value < 0.05

4.2 Discussion

The health of mothers and infants is intricately related. However, studies focusing on the impact of maternal health factors on infant mortality are limited in less developed countries. The present study aimed to assess the impact of maternal health on infant mortality in a poor economic and development setting. I used previous studies to identify the most comprehensive linkage between maternal health and infant mortality in the context of Ethiopia using the most recent Ethiopian Demographic Health Survey. Similar to other sub-Saharan countries, the infant mortality rate in Ethiopia is one of the highest in the world (48 deaths per 1000 infants) indicating the government`s weakness to respond the poor pregnancy and birth outcomes in the country. This study demonstrates that the high rate of infant mortality is partly due to the poor maternal health in the country. The results is consistent with the results of Wagstaff & Claeson (2004), Chan (2013), Vogel (2014), Ronsmans (2010) & Braitstein (2013) that explain a direct relationship between maternal health and infant mortality.

The results also fit with the theory of modernization that states industrialization (and the associated economic development) increases human well-being and reduces infant mortality. In another way, underdevelopment and the related poverty level lowers human well-being and increases infant mortality. Health is one of the most important measures of human well-being. Although this study was conducted in one low economic setting, the finding is generalizable to other sub-Saharan African countries because most of the women residing in these countries experience a higher maternal and infant deaths due to a lower level of living standards and the region has the poorest health systems as compared to other regions in the world. The maternal health indicators considered in the current study include antenatal visits, delivery by cesarean section, maternal vaccination, family planning, place of delivery, and postnatal care. The empirical analysis of this study reveals that five out of six of these maternal health factors, namely, antenatal visits, delivery by cesarean section, maternal vaccination, family planning, and postnatal care were found to be the determinants of infant mortality in the country.

Antenatal care is one of the determinants of infant mortality in the study reflecting that the high rate of infant mortality in the study area is partly due to the reason that infants of mothers who didn`t use antenatal care service couldn´t receive information about the possible health complications arising during their pregnancies. As a result, they haven`t been treated for complications that led them and/or their newborns to die which were preventable. This result is

also consistent with the previous studies such as McCaw-Binns (2004), Reynolds & Tucker (2006), Yuster (1995), Gajate-Garrido (2013), Habibov and Fan (2011), and Maitra (2004) which shows the importance of antenatal care to reduce infant mortality rate.

Moreover, preterm birth could be one of the reasons of the high number infant deaths in the country that it would be managed if mothers of the deceased infants used antenatal care during their pregnancy period. This is consistent with Roser`s (2013) that explain preterm birth as one of the leading causes of infant deaths in the less developed countries, like Ethiopia. The deaths of infants would also be reduced if mothers of the infants got quality antenatal care during pregnancy for more other reasons too. For one reason, they could have received vaccination for tetanus and other vaccinations depending on the status of the fetus and her health during antenatal visits. For another reason, underweight mothers could be supplemented with micronutrients from her health providers to prevent preterm birth and low birth weight which are one of the leading causes of infant mortality in developing countries including Ethiopia. They could also be informed about the type of delivery they should have depending on the position and health status of her fetus if they received antenatal care.

Furthermore, studies show that if a woman uses antenatal care, she is more likely to deliver at health facilities, receive vaccination, and use postnatal care. The result fits with the finding of Peter (2009) that states mothers who receive ANC are more likely to delivery at health facilities. Hence, mothers of the infants who didn`t receive antenatal care were less likely to be vaccinated which could cause a higher risk of infant deaths, mainly due to tetanus. Tetanus is a disease caused by a bacterial infection and it can be transmitted from mother to newborn during a vaginal birth. In general, a woman attending proper antenatal care can receive information on pregnancy-related complications and can get appropriate treatments that can save both her life and life of her child. Postnatal care is also another determinant of infant mortality in this study implying infant mortality could be reduced if mothers of the infants got appropriate treatments and education on care for themselves and their infants that could save them and their newborns from maternal and infant deaths after delivery. Most of the deliveries took place at home in the study and postnatal care is not given for home deliveries in the country. As a result, the majority of the mothers couldn`t get postnatal care which contributed to the deaths of infants in the country.

Significant linkages exist between maternal health, infant mortality, and family planning in the study implying that a considerable portion of mothers of the infants didn`t use family planning, and hence they didn`t limit and spaced their children. However, several studies identified that lower birth intervals (mostly less than 2 years) are one of the lead causes of maternal and infant deaths. Therefore, it makes sense that the high rate of infant mortality was partly due to unwanted pregnancies in the country. Hence, some of the deaths of the infants could be reduced by avoiding unplanned pregnancies, if mothers of the infants used family planning in the study area. The result is consistent with the findings of WHO (2004), Angeles (2004), Bulatao & Ross (2003), Hakim (2003), and Midhet (1998) that identified a strong linkage between maternal health, infant mortality, and contraceptive use.

Moreover, the significance of family planning in the hierarchical model shows that family planning was the determinant of the variation in infant mortality among the regions in Ethiopia. This implies that there is no equity in the allocation of maternal health facilities among the different regions of the country. That means, women in some regions get better family planning services than other women living in some other different regions in the country. As a result, mothers at a higher risk of pregnancy-related complications in some regions were not treated while mothers at a lower risk in another region were given health facilities due to unfair allocation of scarce resources in the country.

5 Conclusion

This thesis aimed to investigate the role of maternal health on infant mortality in Ethiopia. The study reveals that almost all maternal heath factors have significant contributions to the high infant mortality rate in the country. This indicates that poor maternal health contributes to the poor pregnancy outcomes in the country. Moreover, the study demonstrated that there is no equity in the distribution of health facilities among the different ethnic groups (regions) in the country. Overall, the discussion in section 4.2 indicates that the study meets its aim.

Evidences on the influence of maternal health on infant mortality are limited in the context of Ethiopia. And hence, the result builds on existing evidence that improving living standards in the form of maternal health is important for the reduction of infant mortality in lower economic settings, specific to the case of Ethiopia. Moreover, the results can be of direct practical relevance to the government of Ethiopia for its strategic plans associated with maternal and infant health. This is because the study can be used as a reference for policymakers and health planners to make effective decisions in line with the country`s ambitious goals of lowering infant mortality by 2030. Policymakers should take in to consideration the fact that as women survive and thrive, their children are more likely to survive and thrive.

There are more than 1 million refugees residing in Ethiopia which weren't included in the current study. Thus, I suggest for future researchers to study the impact of maternal health on infant mortality in such a disadvantaged community with a more fragile health systems.

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7 Appendixes

Appendix

***Table 7.1**: Omnibus Tests of Model Coefficients*

		Chi-square	df	Sig.
Step 1	Step	19,656	7	0.006
	Block	19,656	7	0.006
	Model	19,656	7	0.006*

*Significant at 0.05

***Table 7.2:** Categorical Variables Codings*

		Frequency	Parameter coding
			(1)
PNC	No	1351	1.000
	Yes	1343	.000
Delivery by caesarean section	No	2439	1.000
	Yes	255	.000
Maternal vaccination for tetanus	No	629	1.000
	Yes	2065	.000
Family planning	No	1488	1.000
	Yes	1206	.000
ANC	No	908	1.000
	Yes	1786	.000