DETERMINANTS OF UNDER-5 MORTALITY IN RWANDA

By

JOSIANE DUSABE

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DECLARATION

I declare that this research paper is my original work and that it has not been presented for a degree award in any other university or institution.

Signature …… Date……

JOSIANE DUSABE

X50/77262/2015

This research paper is submitted for the award of the degree of Master of Arts in Economics with my approval as the university supervisor

Signature ……. Date ……

DR. MARTINE OLECHE

DEDICATION

In memory of my parents;

Marie Rose NYIRANYANGE and Aphrodis MUNYANDINDA; both of whom gave me the foundation of something they have never enjoyed.

In memory of my young sister;

Josepha TUYISENGE.

May their souls rest in Eternal Peace.

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The views expressed in this paper are my own and I solely bear the responsibility for any errors and/or omissions in this paper.

ABSTRACT

This study investigates the main determinant of under-5 mortality in Rwanda. The study uses primary data from Rwanda Demographic Health Survey 2014-15. A discrete-time survival model with frailty (catered for unobserved heterogeneity) is applied to establish the effect of proximate variables, socioeconomic variables and environmental variables on under-5 mortality. Two different models were estimated. One examines if infant mortality (the probabilities of dying between birth and 11 months); and their child mortality (the probability of dying between 12 months and 59 months) are relatively impacted differently by covariates. The results show that unfavorable children and mother's characteristics and household characteristics are associated with high likelihood of mortality.

The results utterly show that health care facilities are crucial for childhood mortality. Furthermore, the results show that exclusive breastfeeding, long birth spacing, being born at hospital, access to improved sanitation; access to safe source of drinking water and the use of low-polluting cooking fuel are the most important determinants of childhood survival in Rwanda. On the other hand, the result show that short birth spacing, high birth order, not being breastfed and the use of high polluting cooking fuel are statistically associated with high mortality during infancy age while unsafe source of drinking water, unimproved sanitation, high polluting fuel, not being breastfed, and short birth spacing are statistically associated with high probability of mortality during childhood age. Despite household size being favorable during infancy age, it is unfavorable at childhood age period because a big number of household members are associated by high risk of mortality. In conclusion, improvement in socioeconomic condition of household is important in reducing childhood mortality. Furthermore, a compulsory secondary education level is crucial in reducing under-five mortality in Rwanda.

LIST OF ABBREVIATIONS

CHWs	Community Health Workers
DHS	Demographic and Health Survey
EICV	Enquête Intégrale sur les Conditions de Vie des Ménages (Integrated Household Living Conditions Survey)
GDP	Gross Domestic Product
GNI	Gross National Income
HH	Household
HIV/AIDS	Human Immunodeficiency Virus/Acquired immunodeficiency Syndrome
IMR	Infant Mortality Rate
MDGs	Millennium Development Goals
MoH	Ministry of Health
NISR	National Institute of Statistics of Rwanda
NN	Neonatal Mortality
PNN	Postneonatal Mortality
RDHS	Rwanda Demographic and Health Survey
RMNC	Reproduction, Maternal, Newborn and Child health
SDGs	Sustainable Development Goals
SSA	Sub- Sahara Africa
U5MR	Under-Five Mortality Rate
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund

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CHAPTER ONE

INTRODUCTION

1.1 Background

Infant and child mortality are powerful indicators of overall health situation of a country. As we moved from Millennium Development Goals (MDGs) to new goals Sustainable Development Goals (SDGs) to be adopted by the years 2030, which includes a set of 17 goals[1]. Thus, will finish the job of the MDGs and ensure none is left behind. Child health and reduction of under-5 mortality is one of SDGs goals number 3[2]. Great improvement has been made globally in reducing childhood mortality in order to attain these goals and targets related program[3] have received renewed policy and research attention.

Recently, the progress in reducing childhood mortality has been accelerating. This progress has saved millions of lives of children younger than 5 years of ages. However, despite these improvements, progress is remaining deficient to achieve the worldwide target. Globally and regionally, according to UNDP (2015), since 1990, under-5 deaths has steadily declined from 12.7 million to 5.9 million in 2015, about 16,000 children deaths every day are compared with 35,000 in the 1990's, where 1.8 percent of annual rate declined during 1990-2000 to 3.9 percent during 2000-2015.

Overall, African countries observed significant decreases during 1990 to 2012, under-5 mortality declined from 146 deaths to 65 deaths per 1,000 live births, a 55.5 percent of deaths beside the target of two-third mortality reduction. Africa continent is still the region with the highest rate of U5MR globally, accounting for 1 in 9 child deaths under age of five. Encouragingly, Sub-Saharan Africa has made significant progress in reduction of U5MR, with annual rate raised from 1.6 percent during the 1990's to 4.1 percent during 2000-2015. This improvement has saved around 48 million lives of children under age of five who survived to see their fifth birthday (UNICEF, 2013).

However, despite this substantial gain in SSA, there is still a way towards to meet the new target of SDGs globally and regionally, particularly Sub-Sahara Africa because 1 in 12 child

[1] Fight inequality and injustice, end poverty, good health, tackle climate change, zero hunger, etc

[2] SDGs goal number 3: Good Health and well- being. Target number 3.2 stipulate end preventable deaths for all children under-5 years of age by the year 2030, at least 12 deaths and 25 deaths per 1,000 live births neonatal and U5MR respectively.

3 Such as maternal health, nutrition, immunization, poverty reduction, education, improvement of environment conditions, and economic growth.

deaths of U5MR before the age of five, which is very high compared to 1 in 147child death of U5MR in high-income countries (UNICEF, 2015).

1.1.1 Country's Background

Rwanda is a small, low-income and landlocked country in East Africa region. It is bordered to the west by the Democratic Republic of Congo, to the east by Tanzania, to the north by Uganda and to the south by Burundi. The country is divided into 5 Province; West province, North province, South province and East province and the City of Kigali. Rwanda has a population of about 11.4 million in 2014 and a GNI of $ 1450 as of 2013 (World Bank, 2014). According to Census 2012[4], Rwanda is among the most densely population country in Africa with an average of 415 inhabitants per square kilometer.

Since the 1994's Genocide, Rwanda has registered remarkable progress, mainly in promoting good governance and well- being of its citizens, especially the poor. Although, despite improvement of economic growth and development. Globally, Rwanda is still among the poorest countries with 39.1 percent of the population living below the poverty line (EICV4[5], 2013/2014). Rwanda's economy is largely dependent on rain-led agricultural production (supported by small semi-subsistence production) which contributes 35 percent to GDP and employed approximately 80 percent of total population. The country's limited resources[6], mainly agricultural, are not sufficient to ensure the strict dietary needs of its population. Other related indices are health, education, and inequalities. Primary school and secondary school attendance rates have increased progressively in last previous years; with secondary school enrollment, up to 41 percent (gross enrollment in 2013/2014). EICV 4, (2013/2014) show that economic inequalities have reduced. During 2000 to 2014, the Gini coefficient dropped from 0.51 percent to 0.45 percent (EICV, 2013/2014). Rwanda has the best gender equality record.

Health indicator (NISR, 2015) shows that the life expectancy at birth estimated at 64/67 years male/female respectively, maternal mortality has been reduced from 740 deaths in 2005 to 210 deaths in 2014-15 per 100,000 live births. Infant mortality has been reduced dramatically from 86 deaths in 2005 to 32 deaths in 2014-15 per 1,000 live births. Under-5MR has reduced steadily from 152 deaths per live births in 2000 to 50 deaths in 2014-15 compared to a new target of SDGs to reach at least 12 deaths per 1,000 live birth of U5MR in 2030.

[4] Fourth Population and housing Census, Rwanda, 2012
[5] EICV 4: Fourth Rwanda Integrated Household living condition Survey 2013/2014
[6] High transport cost, low natural resource base, land limited with high population growth of 3% in 2012

1.1.2 Childhood mortality in Rwanda

Rwanda, as a developing country has been taking good measures in accelerating progress towards a preventable reduction in maternal and childhood mortality and the projection for the coming years, are positives. It is in this context that Rwanda was ranked as one of the 10 "fast-track"[7] countries in 2012 in making improvement of women and children's health (MoH, 2014). The leading causes of childhood mortality in Rwanda are respiratory infections, HIV, malaria, septicemia, diarrheal disease, and malnutrition.

Table1: Early Childhood mortality rates in Rwanda

Period preceding the survey	Neonatal Mortality (NN)	Postneonatal Mortality (PNN)*	Infant Mortality (1q0)	Child Mortality (4q1)	Under-5 Mortality (5q0)
0-4	20	13	32	19	50
5-9	25	26	51	35	84
10-14	37	46	83	73	150
*****computed as difference in neonatal and infant mortality rates					

Source: Rwanda DHS final report 2014-15 (All rates are expressed per 1,000 live births)

Neonatal mortality is defined as the probability of dying within the first month of life while Post-neonatal mortality is defined as the difference between infant and neonatal mortality. On the other hand, Infant mortality is defined as the probability of dying before 12 months of living, Child mortality is the probability of dying between 12 months and 59 months of life and lastly, Under 5 mortality is the probability of dying between birth and 59 months of life.

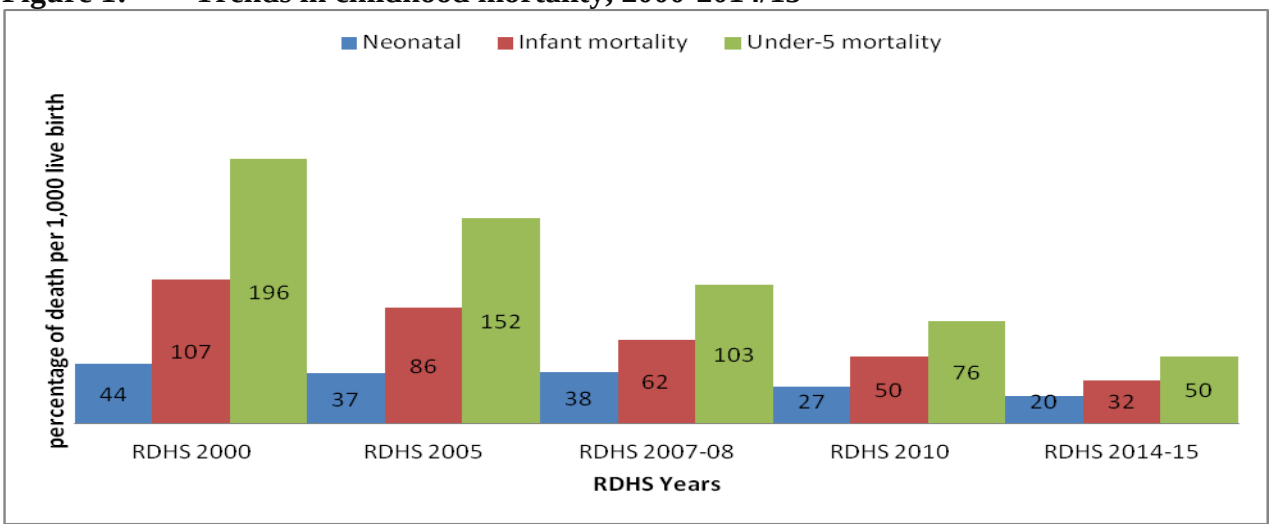
Table 1 presents a view of childhood mortality for 5 years' period preceding the survey. Infant mortality from 51 deaths in 2010 to 32 deaths in 2014-15, under-five mortality from 84 deaths in 2010 to 50 deaths in 2014-15. This improvement in childhood mortality results essentially from strong community involvement and the implementation of powerful management strategic of children illness within health facilities, the introduction of new vaccines and improving nutrition for both mother and their children. After Genocide of 1994, the government of Rwanda has put strong efforts on political stability, trying to build up the national economy and unity of population. In the 2000's, the government of Rwanda

[7] Countries in 2012, who have been show accelerating progress towards preventable reduction in maternal and childhood mortality

established the program identified as Rwanda Vision 2020, 20 years strategy to lift the country from low-income to middle-income status and other indicators by the years 2020.

From this framework, it stipulates various interventions to improve health status (Maternal and child health). This sector has received increased government expenditure associated with health sector decentralization by prioritized RMNCH throughout the policies of focusing on health system, and integration of outside health sectors[8], this combination of various factors have played an important role in order to improve RMNC outcomes (e.g., full child immunization, exclusive breastfeeding for at least six months, improvement in socioeconomic conditions). Other intervention targeting childhood includes community health workers (CHWs)[9], who provide essential health services (especially under-5 child and pregnant women) at the village level.

Figure 1: Trends in childhood mortality, 2000-2014/15



Source: Rwanda DHS 2014-15 final report

Rwanda Vision 2020 framework stipulates to reduce childhood mortality at least 27 deaths per 1,000 live births by the year 2020[10]. Despite the progress towards the reduction of childhood mortality in Rwanda, many more efforts are required in order to achieve this target, and a refreshing assessment of main determinants of childhood mortality is an asset.

[8] Such as education; innovation and research; water and sanitation; infrastructure; nutrition; etc…
[9]There are the 3-volunteer elected from each village trained by the MoH, to provide curative services e.g: for malaria, diarrheal diseases, expanding the family planning coverage, children immunization, etc...
[10] In 2012, the Government Revised Vision 2020 target e.g: child mortality, maternal mortality, etc…

Existing literature on child health has outlined the determinants of childhood mortality. These studies focused on specific variables of choice. For instance, Rutstein (2000) considered 5 categories of explanatory's factors such as socioeconomic determinants[11], fertility behavior[12], environmental contamination[13]; the nutritional status[14]and child and maternal health status to be more important in determining childhood mortality.

Kembo and Van Ginneken (2009) examine the determinants of childhood mortality in Zimbabwe using (DHS, 2005-2006). The results suggest that the factors associated with mortality were relative different between those of child and those of infant mortality. Similarly, results to the study of Omariba et al. (2007) conducted in Kenya; found that hygienic factors and socioeconomic variables are more significant in child mortality while bio-demographic factors are more related to infant mortality.

Kaldewei and Pitterle (2011) in Jordan explain that behavioral factors such as smoking, breastfeeding, and birth spacing bear weight in explaining infant mortality. Ezeh et al. (2015) show that factors explaining mortality include: age of the mother, low socioeconomic and cultural status and education status of the mother, environmental factors (sanitation facilities and access to clean water). According to Schultz, (1984), rural region conditions appear to favor higher child mortality, higher fertility; lower labor force participation by women, and lower school enrollment rates, most migration in low-income countries is from rural to urban areas.

Mother education plays a fundamental role in reducing childhood mortality. Caldwell (1979) indicates that educated mothers utilize health facilities and available resources to improve their own health and that of their children because mother's level of education influences the decisions being taken in their home and better health seeking practice. Niragire et al. (2011) found the most factors affecting childhood mortality in Rwanda included the household's socioeconomic status which is the most important determinant of child mortality, followed by mother's and father's skills level and the province of residence with a significantly weak effect. Similar results found by Musafiri et al. (2014), the trends and levels of childhood mortality in Rwanda were characterized by a difference in the region rural/urban, the

[11] Parent's education, place of residence; mother's and father's work status and wealth quintile.
[12] Birth order, mother age at birth, birth spacing
[13] Access to sanitation facilities, source of cooking fuel, access to safe drinking water,
[14] Nutritional of the mother during pregnancy and after pregnancy, breastfeeding, infant and child feeding,

maternal level of education and household wealth. The high rate of mortality was associated with rural areas, with no education level and low household wealth.

Review of literature on childhood mortality reveals that a set of factors affect childhood mortality. However, predictors of childhood mortality are also changing over time. Hence more research is necessary using the current data to identify the determinants of childhood mortality, in order to know where programs need to be strengthened. Therefore, the interest of this study is to examine the main determinants of under-5 mortality in Rwanda.

1.2 Statement of the Problem

Vision 2020 is anchored to lift Rwanda from a low-income country to a middle-income country by the year 2020. The growth of the Rwandan economy depends on the aggregate increase in economic productivity of the country and the wellbeing of its population because childhood mortality rates reflect a country's socioeconomic situation (UNDP, 2007) as well as the quality of life of the population.

Good health and nutrition boost the productivity of human capital. Furthermore, it enhances economic growth and contributes to the reduction of poverty and the realization of the vision's social pillar goals on health and education. Child mortality has received extensive attention internationally through Sustainable Development Goals (SDGs). In this regard, Rwanda has made progress in reducing childhood mortality by implementing health policing and increasing health expenditure. However, despite these improvements shown by (Figure 1), childhood mortality is still high at 50 deaths per 1,000 live births. This is in contrast to vision 2020's 27 deaths per 1,000 live births.

This assessment drives the need to establish the main determinants factors of childhood mortality in this study. Recent data of RDHS 2014-15 is used in assessing the impact of current government and stakeholders' intervention strategies, in order to continue enhancing the Rwandans' quality of living and to achieve at least a low rate of childhood mortality. This study proposes to reassess the effect of socioeconomic variables, proximate determinants and environmental variables on under-5 mortality so as to allow them prioritize and allocate limited resources optimally.

1.3 Research Question

i) What is the profile of under-5 mortality in Rwanda?

ii) What is the effect of socioeconomic, environmental and demographics variables on under-5 mortality in Rwanda?

iii) What are the policy implications for the reduction of under-5 mortality rate in Rwanda?

1.4 Objectives of the study

The broad objective of this study is to establish the main determinants of under-5 mortality in Rwanda

The specific objectives are:

i) Establish the profile of under-5 mortality in Rwanda

ii) Establish the effect of socioeconomic, environmental and demographics variables on under-5 mortality in Rwanda.

iii) Establish policy implications towards the Rwanda's Vision 2020 target of reduction of under-5 mortality

1.5 Justification of the study

This study used recent demographic data set, (RDHS, 2014-15) which is more appropriate to consider in assessing the impact of current government intervention and other stakeholders in the health sector in order of financing the priorities given limited resource.

In addition, the study, therefore, provides a snapshot of some key factors where the ministry of health, government, and other stakeholders need to focus to reach the expected levels of child mortality by the year 2020. Finally, the study adds to the existing literature of child mortality in Rwanda especially how factors associated with infant and child mortality are relatively different from those associated with under-5 mortality in Rwanda.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Literature

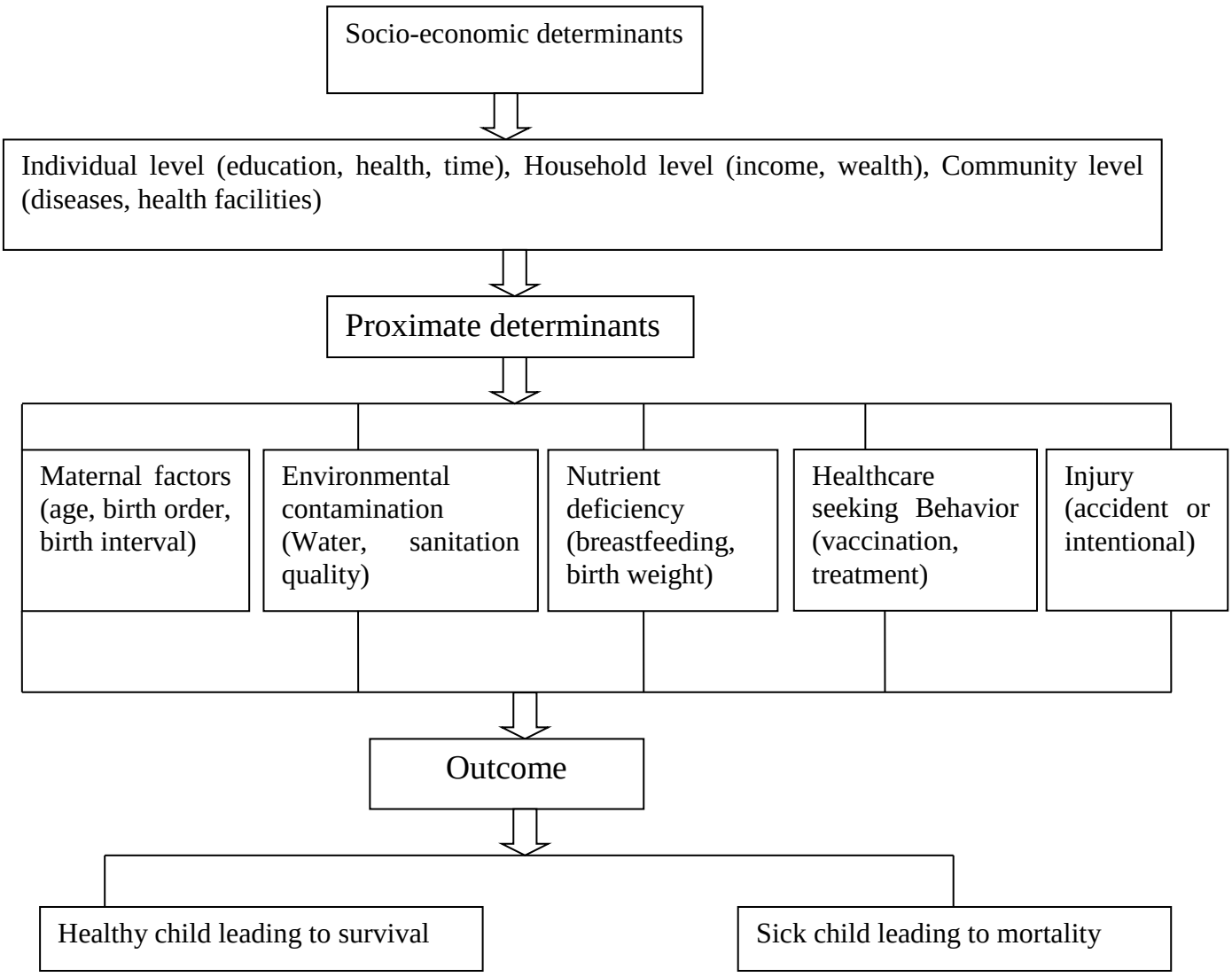
Mosley and Chen (1984) set the childhood survival framework based on the assumption that socioeconomic[15]or exogenous variables and endogenous or biomedical factors[16] affecting childhood mortality operate through a set of endogenous factors. According to (Schultz, 1984, Mosley and Chen, 1984), the endogenous factors are called intermediate variables (intermediate inputs by Schultz) because they represent the middle point connecting childhood mortality and the exogenous variables.

Schultz (1984) in his theoretical framework suggests the way to estimate empirical determinants of child health based on health production function and how households relate to health input and child health. He demonstrates how child survival may be viewed among other endogenous household variables that may be modified by economic and demographic choices. Child survival may be interpreted as directly conditioned on exogenous constraints and environment condition such as place of residence (rural or urban), public program, price, wages, preferences, marital status, individual biological and economic endowment.

Mosley and Chen (1984) categorized these determinants into five groups: environmental contamination, injuries, maternal factors, nutritional status and child illness treatment factors. According to them, 97 percent of children born are estimated to survival until five years of age. However, the influence of socioeconomic, environmental factors and biological are driving forces behind the reduction in survival probabilities. The disease and nutrient deficiencies, which are observed in survival population, are cumulative series of biological indicators of proximate determinants.

[15] Cultural, social, economic, community and regional conditions
[16] Breastfeeding patterns, hygiene, sanitary measures and nutrition

Figure 2: Analytical Framework of child survival by Mosley-Chen



Source: Adapted from Mosley and Chen (1984)

Figure 2 illustrate how the proximate determinants operate on dynamics of population's health. Maternal factors, environmental contamination, nutritional, healthcare and injury affect child mortality or child survival.

However, all these determinants should operate through these variables toward child survival. Maternal factors (birth spacing, mother's age at birth and birth order), environment contamination and nutrient deficiency influence child health leading to child survival. Children born in good environmental condition and well-taken care are expected to survive as

opposed to these born in deplorable conditions. Nutrition influences the survival of children when nutrients are available to both mother and their children during pregnancy and lactation.

At the individual level, individual productivity is measured by his/her skills which are captured by the education level, time and health. Father's level of education is strongly related to household income and occupation. Father's skill determines household's assets and strongly influence preferences and attitudes of consumption goods and child healthcare services. This effect is more significant when educated fathers are married to the less educated mother while mother's education is different because it affects directly child survival due to biological factors by influencing choice and increasing her skills in healthcare practice and time devoted to child care like hygiene and treatment of diseases. Mother's nutrition, health status and her reproductive pattern influence the survival of their children.

At the household level, child health and mortality also depend generally on household's economic status. Household variables such as income and wealth affect the availability of goods, services, and assets owned by the members of the households. Accessibility of basic minimum food ensure balanced diet. The quantity of water taken is a determinant of child survival where quantity affects bathing, washing and cleaning, and quality for drinking and food preparation.

Place of residence, housing size, ventilation, crowded condition and sanitation with a separate room assigned for sleeping, cooking, toilet and bathing and storage of foods and water, and electricity are vital in reducing child mortality. In addition, basic infrastructure influences health through the relative price, service, and information.

This study adopts this theoretical framework of understanding the factors associated with survival and mortality of U5MR and it guides in the choice of dependent and independent variables based on the assumption that proximate determinants (economic, demographic and medical mechanism) affect the probability of child survival through a set of biological mechanism.

2.2 Empirical Literature

The 1990's were characterized by rapid declines in both infant and child mortality rates resulting from global initiatives to improve child health. Existing literature on child health

has outlined factors associated with child mortality. For instance, Rutstein (2000), considered 5 groups of explanatory factors like fertility behavioral, nutritional status, maternal and child health, environmental health and socioeconomic status to argue that these factors are strongly linked to declining trends in childhood mortality in the 1990s. According to him fertility behavior had 3 characteristics associated with childhood mortality: the high rate of mortality which associated with high order of births, preceding birth spacing that is less than 24 months or 36 months, with a mother who was younger than 18 old or more than 35 old at time of births and being the first born.

Nutritional status and high mortality were observed among poorly nourished children and those born underweight[17], contrary to those children, who has been breastfeeding at least 6 months, begin eat solid food from the age of 7 months and breastfeed well in 2 years which correlated with lower mortality. Maternal health factors like (postnatal care; delivery assistance and health facilities) are connected with the lower level of mortality among those of under age of five. Lower mortality of U5MR was strongly correlated with children who has been fully vaccinated and taken to a medical facility because he/she suffers illness such as diarrhea, acute respiratory infection, fever and malaria among other illness.

Environmental factors are strongly associated with socioeconomic status, place of residence, sanitation facility, the source of drinking water and quality of housing. He found a household with safe drinking water, safe toilet facilities and dirt floor was significantly correlated to lower rate of mortality. Improvement of socioeconomic status is significantly associated with lower rate of mortality. Women with at least primary education and those who can access electricity have a lower rate of mortality. Children living in urban areas were correlated with a lower rate of mortality than children's living in rural areas. The finding shown explain how all the explanatory variables (maternal care, hygiene factors, vaccination, medical treatment, nutritional status, education) have participated strongly during the 1990's in explaining child survival in developing countries.

Kembo and Van Ginneken (2009) examine the determinants of childhood mortality using (DHS, 2005-2006) in Zimbabwe. This study suggests that the factors determinants of infant mortality were relatively different to those of child mortality.

[17] because maternal nutrition during pregnancy affect birth weight

They employed multivariate hazard analysis model, and they established that maternal and paternal educations are both correlated to child mortality. Sanitation facility (piped drinking water and flush toilet to household's member) was more strongly correlated with child mortality while birth order and preceding births intervals are main determinants of infant mortality. The results confirmed the hypothesis which stipulates that exogenous factors are principal during the childhood age while endogenous factors are principal during infancy.

Omariba et al. (2007), finding from Kenya DHS, the result of standard Weibull survival model confirmed that bio-demographic factors are dominant determinant during infancy while socioeconomic, cultural and sanitation facility is more significant during childhood age.

2.2.1 Socioeconomic Determinants

Existing literature gives great attention to education as an important determinant of child survival. Several studies show that education is linked to family economic status. Mother's level of education is correlated with the lower level of childhood mortality because women with some education perform better in family health and sanitation. Caldwell (1979) employed data from Nigeria conclude that education allows women to break away from tradition, to better utilize what is available in the house and in the community, and to make an independent decision regarding their own health and health of their family. Thus it leads to greater utilization of modern health care.

Caldwell (1979) argue that mother's education lowered the rate of childhood mortality through better feeding, more hygiene, and care practice which lead to better health care behavior. Similarly, Kabubo-Mariara et al. (2012) found that educated women are willing to use modern contraceptives because this has a large impact on lowering the risk of mortality, other factors held constant. Hobcraft (1993) concluded that educated women who enter into marriage or motherhood later in life, have fewer children and take care of their children, immunize them and utilize prenatal care. Similarly, Alves and Belluzo (2005) analyzed at the individual level, the determinants childhood mortality in Brazil, and found that education was ranked first in determining child survival. Girma (2007), found education level positively impact on nutrition level because educated women are more informed on how to utilize available resources to improve their own nutrition status and that of their family.

Medrano et al. (2000) used mother education as a measure of health knowledge and concluded that child health would be improved with an accumulation of knowledge. Other several studies, which have outlined the importance of mother's education on childhood mortality per example Uddin and Ullah (2009), Mutunga (2004), Ezeh et al. (2015), Niragire et al. (2011) and Musafiri et al. (2014). Maternal education can also be a proxy for determining other household characteristics.

Bawah (2001) conducted a study in Africa whose objective to establish the association between child survival and the socioeconomic in the context of standards of living. This study employed negative binomial regression model that takes into account unobserved heterogeneity using census data from Botswana, Lesotho, and Zambia. He concluded that children, who live in smaller households, are expected to survive compared to those living in larger households. The implication here is that living in poor conditions is, therefore, likely to increase the risk of illness which leads to childhood mortality. Alves and Belluzo (2005), found at the individual level in Brazil, besides mother's education, other economic variables such as income per capital were shown to be second strongest in determining child mortality outcomes followed by sanitation services availability.

Furthermore, place of residence influence childhood mortality. Schultz (1993) argued that among low-income, agricultural households, the rural mortality rate is higher compared to the urban family because among other reasons, access to health facilities is costly in rural areas than in urban areas. A similar study done in Kenya by Muriithi and Muriithi (2015) argue that children born to a mother living in rural areas have a higher probability of dying because access to adequate health facilities is costly and better sanitation too.

Kabubo-Mariara et al. (2012), employed survival analysis to model children survival in Kenya. She found that children living in rural areas have a higher likelihood of dying because they are more subjected to poverty than urban children. Similar to the findings by Ezeh et al. (2015), they used multivariate model analysis on Nigeria DHS data and found that poor households who live in rural areas have the higher risk of mortality among Nigerian children. Mugarura and Kaberuka (2015) employed random effect regression model to Uganda DHS data to investigate the factors associated with childhood mortality and found that household wealth to be significant to child survival. Children born in the rich family have the high probability of survival than those who born in the poor families. Also, children born in the

middle class have a lower probability of dying than those of poor family. Zele et al. (2003) found in Bangladesh that children born to the poor family are more likely to be undernourished with the risk of dying than those of wealthier families.

Labor market status has been found to play a role in child survival. Muriithi and Muriithi (2015) used Cox hazard model to determine child mortality in Kenya and found that mothers whose occupation is sales agent have a high risk of their dying children as compared to those of mother's occupation are functionary or teachers. However, in a study carried by Uddin and Ullah (2009) for developing countries, they argue that father's occupation played an important role in child survival. They found that mother's occupation had a weak effect but an opposite effect is observed on a father's occupation which had a great impact on child mortality. High mortality rate was observed among fathers employed in agriculture compared to those service holders.

Households with a low standard of living experience high rates of mortality. Furthermore, poverty, diseases, malnutrition have been highlighted as main determinants of child mortality. Other studies which have highlighted poverty as a major determinant factor of childhood mortality as spearheaded by Ezeh et al. (2015), Kabubo-Mariara et al. (2012), Zele et al. (2003) and Bawah (2001).

There are studies which have highlighted epidemic and diseases to be the highest cause of childhood mortality. There are studies which have shown the strong direct and indirect links between HIV/AIDS and childhood mortality. Hill et al. (2001) have made a conclusion that in Kenya, HIV epidemic was the most probable cause of increased child mortality in the late of 1980s and middle 1990s and not the socioeconomic or demographic characteristics. Villamor et al. (2005) employed Cox proportion hazards model in Tanzania and found that the strongest predictors of mortality in Dar-es-salaam medical Centers were HIV infection, among other predictors. Mustafa et al. (2008) using Kenya DHS (2003) argued that the HIV/AIDS incidences increase the risk of dying at infancy periods in both areas (urban and rural). Jones et al. (2006) indicated that in India diseases, like diarrhea, pneumonia and tetanus, premature deliveries, bacterial and malnutrition are the main causes of child mortality.

2.2.2 Proximate Maternal Determinants

Several studies have found an important relationship between childhood mortality and fertility behavior. These studies witnessed evidence that mother's age at birth, birth spacing and birth order are associated with childhood mortality. However, children born to younger and older mother, those born after a short birth and those born with high order (4 and above) experienced the higher risk or mortality. Hobcraft (1993); Mcdonald and Rutstein (1985); show that teenage and older mothers experienced elevated risk of child mortality. Very young mothers may experience difficulties during pregnancy because they are biologically immature and their inexperience in taking care of children increases the probability of dying. Old mothers may experience age-related complication during pregnancy and delivery.

Kembo and Van Ginnecken (2009) used multivariate analysis on Zimbabwe DHS survey to demonstrate that maternal ages (high than 40-49 ages and less than 20 ages) are correlated with high risk of mortality during infant mortality than during child mortality and multiple births are associated with high rate of mortality. This is similar to the study done by Mugarura and Kaberuka on Uganda data set found that child born to a young mother and old mother increased the risk of dying before 5 years of age. Hence this could be explained by the facts that older mothers and teenagers are likely to face the higher risk of mortality because they give birth to a child with low weight.

Several studies have highlighted ages (less than 20 and great than 40) of the mothers at birth. Short birth spacing (less than 18 months after mother's previous birth) associated with high birth order (4 and above) are linked with high probability of mortality as stated by Ezel et al. (2015), Rutstein (2005), Mustafa et al. (2008) and Grummer et al. (1998).

Children with low weight have high mortality risks while child's gender demonstrates varied effects. This fact is due to the historic cultural preferences of a son than a daughter. Mutunga (2004) in an unpublished study found that being born male or twin has a lower probability of survival compare to the contrary. In a study done in Burkina Faso by Becker et al. (2004), it was found that the risk of mortality was twice higher for twins than single birth. They observed high mortality rate during the first 6 months. This is due to the fact that twins born with lower weight and short breastfeeding.

2.2.3 Environmental Determinants

Beside maternal education and standards of living, childhood mortality is influenced by environmental conditions. Several studies support the effect of environmental factors. It has been previously shown that a low socioeconomic position is associated with environmental risk and poor housing conditions. Mutunga (2004) in an unpublished study found that environmental characteristics of the household are statistical significantly related to child survival who lives in households which use safe drinking water, have access to safe hygienic facilities, those using low polluting fuels and those living in a house with improved roofing material for their main dwelling.

Fayehum (2010) analyze eight SSA countries concluded that the lower risk of mortality was among countries which have a high percent of household with safe drinking water, using low-pollution as the source of cooking, improved flooring, improved toilet facilities and children's feces facility. However, she noted that the use of mosquito nets was low among selected countries despite high awareness of malaria diseases. This is similar to study done by Wichmann (2009) examined the association between childhood mortality and the utilization of dirty cooking fuel and heating fuel in South Africa households. The result suggested that contact with heating dirty fuel is correlated with childhood mortality in South Africa, after controlling for variables such as the age of mother at birth, the source of water, household crowdedness and wealth index.

Van der Klaauw, and Wang (2004) found the similarity in China that environmental factors affect childhood mortality in rural China. They employed a parametric hazard rate model on child survival. Their results showed that a high number of child survival can be achieved by providing sanitation facilities, providing access to electricity, encouraging maternal education and reducing indoor air pollution. In a related study, Wang and Jacoby (2004) found using cleaned cooking fuel, access to safe drinking water, improved hygienic facility and immunization reduced diarrhea diseases in rural areas.

Kembo and Van Ginnecken (2009) study carried in Zimbabwe DHS 2005-06 on sanitation, found that households which used piped drinking water and flush toilet had a positive effect on child mortality than infant mortality. Their results support the view that environmental

factors at the household level are especially critical for preventing growth faltering in the foetus and infant which has consequences for a child's subsequent health and survival status.

Also, Antai (2010) and Jinadu et al. (2011), from their findings made a major conclusion that demographic, socioeconomic and environmental factors such as the source of drinking water and hygienic facilities are strongly related to childhood mortality. In addition, use of piped water, availability of toilets and sanitation have been found to reduce the risk of mortality by several studies, like Muriithi and Muriithi (2015); Omariba (2007); Ezeh et al. (2015), Niragire et al. (2011).

2.2.4 Health Seeking Behavior and Breast Feeding

Mother seeking health care service either as curative treatment or preventive plays a significant role in child survival through child health (breastfeeding at least first 6 months, immunization) and nutritional status, and through her own health. Uddin and Ullah (2009) employed multiple logistic regression techniques on Bangladesh DHS survey found that exclusive breastfeeding has effect on child survival because of children who are exclusively breastfeeding, are healthier and survive longer compared to those who did not. Their findings indicated that mortality was high for a mother who had not received an antenatal visit and those during pregnancy had not taken TT injection.

Kaldawei and Pitterle (2011) used Jordan 2007 DHS argue that immunization coverage is associated with child survival. This is a similar finding have argued by Ezeh et al. (2015) that immunization and feeding practices may, in turn, affect child survival positively. A study was done by Ghulam in Pakistan (1996), found that deliveries conducted at home are associated with a high risk of mortality compared to those done in public hospitals.

Muriithi and Muriithi (2015) found that infants born at private hospitals have a lower risk of mortality. This is because private hospitals have better facilities, skilled workers, and drugs as compared to public hospitals. This contradicts the findings by Ogada (2014) in an unpublished study that children delivered in public facilities were less likely to die than those born in private hospitals. Furthermore, Ezeh et al. (2015) for the case of Nigeria found that having caesarean section deliveries increased risks of child mortality.

2.3 Overview of Literature

From the literature review, it is clear that household's environmental characteristics, demographics, and socioeconomic variables have an effect on childhood mortality. Similarly, health services and behaviors that promote and increase the stock of health have been found to have a significant impact on child survival, hence, associated with child health status. There is evidence from studies which used both direct and indirect methods to estimates childhood mortality. The sources of the data were mainly Demographics and health surveys (DHS).

Some studies have been carried to demonstrate how the determinants of childhood mortality and how are relatively different during infancy and childhood ages. From the literature, it is suggested that biological and behavioral factors like birth order, breastfeeding status, preceding birth spacing, age of mother at birth, mother's health status and her health care and type of birth are dominant determinants during infancy, less pronounced in child mortality while health care, environmental contamination, malnutrition and source of water and exposure to infections have strong impact on child mortality than infant mortality. However, mother and father and mother's education have both a marginal impact on infant and child mortality.

This paper investigates socioeconomic, environmental and demographics factors in order to assess the main determinants of childhood mortality in Rwanda and how the factors are relatively different during childhood age and infancy because there is lack of study in Rwanda showing that difference. So, this study attempts to fill this gap by adding to the body of knowledge of this important topic. Therefore, this study also takes advantage of using recent national survey RDHS 2014/15 to look at the current childhood mortality and the factors associated with household that may influence child survival in Rwanda.

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter presents the methodology framework used to analyze data, data source and describes how the variables will be measured.

3.1 Conceptual Framework

Rosenzweing and Schultz (1983) argue in their analytical framework that to study child survival and health production framework, a reduced-form demand equation can be used. The model is based on utility theory where households choose an alternative from a set of alternatives in order to maximize their utility. Household maximize utility given as

$$U = f(X, Y, H) \quad (1)$$

Where (U) is utility function of household, (X) is consumption goods which has no effect on health but yields utility, (Y) is consumption of health-related goods that affects child health and (H) is child health status

According to Schultz (1984), child health production function is assumed to be a linear function as

$$H = h(Y, Z, K, \mu) \quad (2)$$

Where (Y) is the proximate biological input to child health[18], (Z) is a child health input[19], (K) is the health knowledge possessed by the household and (μ) is the child health endowment.[20]

Household, therefore choose the proximate biological input in a manner to maximize chances of the health outcome (child survival). These inputs depend on the child health endowment (μ) household preferences, market prices and household physical environmental constraint and household wealth. All these characteristics are assumed as exogenous to the household decisions about behaviors and investment related to child health.

[18] Includes immunization, cooking fuel, water and sanitation environment
[19] Curative and preventive medical care
[20] Genetic or environmental contamination

Household maximize utility (1) given the production function (2) subject to household's budget constraint defined as

$$I = P_x + P_y + P_z \dots\dots (3)$$

Where $(I)$is total household income, (Px) is the price of consumption goods with no direct effect on child health, (Py) is the price of health-related goods and (Pz) is the price of the child specific health input. Maximization of utility equation (1) given (2) and (3) yields a reduced-form equation for goods and health inputs.

3.2 Econometric Model

Discrete- time model analysis was used to examine the main determinants of childhood mortality. Discrete-time survival models are preferable over continuous time survival models because of the following reasons. First, discrete time hazard model can be transforming into binary regression models[21]. Second, discrete time hazard accounts the unobserved individual heterogeneity. Third, in discrete time model is easy to explore the relationship between hazard and time so as to incorporate time-varying covariates[22].

In discrete time survival analysis framework, the risk (probability) is estimated as conditional probability that the event of interest will occur to an individual i in time period j (Kim, 2014).

Therefore, it is important to specify the function of discrete hazard rate. Let T be a non-negative random variable determining the survival time of a particular child. $T \in \{1, \dots k = 59\}$ denotes survival time in month t . Where k indicate the last observation interval and $T = t$ indicate failure time (death). Assume $X_{it} = (x_{i1}, \dots \dots x_{ik})$ indicate the history of the vectors covariates up to the month t , then $h(t|x_{ik})$ is the discrete hazard function given by

$$h_{ik} = P(T = t | T \geq t, X_{ik}) \dots\dots (4)$$

[21] The common binary regression models i.e logit, probit, cloglog (Allison 1982; Singer and willet 1993; Jenkins 1995; Crook and al. 2002; Hess and Persson 2012)

[22] Time-varying covariates refers to the value of some covariates may change overtime (e.g: person's age, income)

Where h_{ik} is the conditional probability for failure in month t given that the child has survive up to the month t . Subscript $i = 1, \dots n$ denotes the total number of all children observed, and X_{ik} is a vector of possibly time-varying covariates.

To assess the effect of a covariate on hazard rate, it is important to specify the functional form for the hazard model in order to estimate the model parameters. Adebayo and Fahrmeir (2002), argued that there are 3 common binary regression models i.e. logit, probit, cloglog. However, this study will use the logit hazard model[23] in equation (5) for ease of analysis.

$$h_{ik} = \mathrm{P}(\mathrm{T} = \mathrm{t}|\mathrm{T} \geq \mathrm{t}) = \frac{1}{1+exp[-(\beta' x_{ik}+\gamma_k+v_i)]} \dots\dots (5)$$

Equation (5) can also be written in logit-hazard form (Singer and Willet 1993)

$$\log h_{ik} \frac{P(T=t)}{P(T \geq t)} = F\left(x'_{ik}\beta + \gamma_k + v_i\right) \dots\dots (6)$$

Where $F(.)$ is a linked function ensuring that $0 \leq h_{ik} \leq 1$ for all $i, k.$ h_{ik} is conditional probability for failure (death) in month t given that the child has survived to month t and given the explanatory variables, x_{ik} is a vector of explanatory variables, β is a vector of parameter to be estimated. The specific independent variables used in this study are discussed in section 3.3. It should be noted that the coefficient which has a negative (positive) sign indicate a negative (positive) impact on the conditional probability (hazard rate). γ_k is a baseline hazard rate which allow the hazard rate to vary across periods. However, a functional form for γ_k can also be specified in order to reduce the number of parameters in the model. v_i is a Gaussian distribution random (frailty) effect indicator that deals with the problem of unobserved heterogeneity.

To estimate the maximum likelihood, we define a binary dependent variable y_{ik}, which takes the value of 1 if child died and takes 0 if is still alive. The likelihood function for a sample of n observation can be conveniently written as:

$$L = \prod_{i=1}^{n} \prod_{k=1}^{j} [(h_{ik})^{y_{ik}} + [1 - (h_{ik})]^{1-y_{ik}}] \dots\dots (7)$$

[23]Other survival studies that have preferred logit hazard model e.g : Jenkins (1995); Kim (2014).

Equation (7) is the likelihood function for the discrete hazard process in terms of (the y_{ik}) and the hazard probability parameters (the h_{ik}). Taking the log of both sides, we obtain a log-likelihood form:

$$\log L = \sum_{i=1}^{n} \sum_{k=1}^{j} [y_{ik} log(h_{ik}) + (1 - y_{ik}) log(1 - h_{ik})] \ldots\ldots(8)$$

Where L express the log-likelihood for all observation from child $i = (1, \ldots., n)$, $k = (1, \ldots, j = 59)$ is time interval (observation in month) in terms of period, y_{ik} is binary dependent variables, h_{ik} is the hazard rate whose functional form has been specified in equation (5). Therefore, interpretation of the results is as follows. A positive coefficient indicates that a particular explanatory variable reduces hazard and vice versa. Maximizing the log-likelihood in equation (8) under the h_{ik} logistic parameterized form in equation (5) provides maximum likelihood estimates. This will answer the second objective of this study.

3.3 Study Variables

The variables of this study are based on Analytical framework of Mosley and Chen (1984) on the factors affecting child survival in underdeveloped countries. Previous studies have outlined the major determinants of childhood mortality. The variables chosen are determined by data availability. The dependent variable (childhood mortality) is estimated in two ways such as mortality from birth to 11 months of age refers as infant mortality and mortality from 12 months age to 59 months refers as child mortality. The outcomes variable is the hazard rate of dying in a specific range of childhood age.

Table 2: Variables Definition, Measurement and priori Expectation

Variables/ Symbols	**Measurement / Description**	**Expected sign**
Dependent variable		
Infant mortality	Mortality from birth to 11 months age	
Child mortality	Mortality from 12 months of age to 59 months age	
Independent variables		
a) Proximate determinant		
Child's gender	0: female 1: male	Girls are expected to have lower mortality than boys
Birth order	Birth order number	High multiple birth lead to high level of mortality
Birth spacing	0:18 months	Increase birth interval lead to

Variables/ Symbols	Measurement / Description	Expected sign
	1:18 months and more	lower the risk of mortality
Age of mother at birth	Mother's age in years	Very young and very old mothers are expected to increase risk of mortality
Breastfeeding	0: not 1: yes	Not breastfeed lead to high risk of mortality
Household's size	number of household members	Uncertain
Place of delivery	0: home 1: hospital	Hospital delivery has negative effect
b) Socioeconomic determinants		
Mother's education	0: No education 1: Primary 2: Secondary and above	Increase level of education is expected to lead to lower mortality
Father work status	0: not working 1: working	Positive impact
Mother work status	0: not working 1: working	Positive impact
Wealth index	0: Poor 1: Rich	Children born in poor families are expected to have high risk of mortality compare to those of rich families
Place of residence	0: Urban 1: Rural	Urban residents are expected to have lower mortality compare to the rural resident
Marital status	0: not married 1: married	Married mothers are likely to have lower risk of mortality
c) Environmental determinant		
Access to sanitation	0:unimproved sanitation facility 1: improved sanitation facility	Availability of improved sanitation facility reduces the risk of mortality
Source of cooking fuel	0: high-polluting fuel 1: low-polluting fuel	Clean cooking fuel is expected to have lower risk of mortality
Access to drinking water	0: unsafe drinking water 1: safe drinking water	Clean drinking water is expected to improve child survival

3.4 Data Type and Source

Primary cross section Rwanda Demographic Health Survey (RDHS) 2014-15 data[24] is used for analysis. This data provides information on population, health, nutrition, fertility, mortality, environmental and socioeconomic conditions and more. It is a nationally representative survey of 12,699 households, 13,497 women aged between15-49. RDHS data collection was conducted from November 9, 2014, up to April 8, 2015, and the final survey report completed in March 2016. As is often the case, childhood mortality comes from women survey questionnaires to capture data on women's birth history. Women were asked the month and year of birth, the age of the child on the date of the interview if alive, and if not alive, the age at death of each live birth.

During the interview, the respondents reported whether a child was born alive and whether or not they were still alive at the time of interview. In case a child died during the observation period, the exact age at which the child died was recorded. All deaths are recorded in months except the deaths that occurred in less than a month; are recorded in days.

Therefore, since the interested of this study is childhood mortality until 59 months of age, we used the right-censored data from birth to 59 months years of age and those who were alive during the time of interview and younger than 5 years.

[24] RDHS 2014-2015 survey data set with the permission of ICF International has downloaded (www.archive@dhsprogram.com) in Stata form.

CHAPTER FOUR

DATA ANALYSIS, RESULTS, AND DISCUSSION

This chapter outlines the empirical analysis. It starts with summary statistics/descriptive statistics then it proceeds by a discrete logistic regression model results. The last section will contain robustness results of logistic regression.

4.1 Summary Statistics

Summary statistics is important because it outlines the results of the preliminary inspection of the data used thereby showing its basic features. This step is critical to conducting any econometric analysis. This study uses RDHS data for 2014-2015. The variables are divided into five main groups: dependent variables (Infant mortality and child mortality); proximate determinants (child's gender, birth order, birth spacing, mother's age at birth, breastfeeding, household size, place of delivery); socioeconomic determinants (mother's education level, mother's and husband's occupation, wealth index, marital status, place of residence) and; environmental determinants (access to sanitation, source of drinking water, source of cooking fuel).

Table 3: Descriptive Statistics

Variable	Mean	Median	Std. dev	Min	Max	Skewness	Kurtosis
Infant mortality	0.281	0	0.450	0	1	0.972	1.945
Child mortality	0.032	0	0.176	0	1	5.318	29.28
Gender of child	0.509	1	0.500	0	1	-0.035	1.001
Birth order	2.929	2	1.953	1	14	1.151	4.098
Birth spacing	0.861	1	0.346	0	1	-2.087	5.357
Mother 's age	37.48	38	7.306	15	49	-0.317	2.287
Breastfeeding	0.370	0	0.483	0	1	0.541	1.292
Households size	5.661	6	2.009	1	22	0.542	4.107
Place delivery	0.904	1	0.295	0	1	-2.739	8.503
Husband works	0.991	1	0.095	0	1	-10.36	108.3
Mother works	0.888	1	0.316	0	1	-2.453	7.016
Marital status	0.877	1	0.329	0	1	-2.293	6.260
Residence	0.187	0	0.390	0	1	1.609	3.588
Wealth	0.360	0	0.480	0	1	0.581	1.338
Cooking fuel	0.163	0	0.369	0	1	1.827	4.337
Sanitation	0.069	0	0.254	0	1	3.388	12.48
Source of drinking water	0.688	1	0.463	0	1	-0.814	1.662
Mother's education							
1: no education	0.246	0	0.431	0	1	1.180	2.393
2: primary	0.670	1	0.470	0	1	-0.724	1.524
3: Secondary +	0.084	0	0.277	0	1	3.003	10.02

Source: own computation

Results from Table 3 show that the mean and median of the variables are almost similar and they have relatively small values of standard deviation. This indicates normality in the distribution of variables. Infant mortality, child mortality, birth order, breastfeeding, household size, residence, wealth, cooking fuel, sanitation, mother education level (no education and secondary and plus) are positively skewed. Hence, their distributions have long right tails. Conversely, the gender of the child, birth spacing, mother's age, place of delivery, husband work status, mother work status, marital status, source of drinking water, mother education level (primary) are negatively skewed. This indicates they have long left tails.

Kurtosis measures the thickness of the distribution of tails, and it is three for a normal distribution. Results in table 3 indicate that infant, the gender of the child, mother's age at birth, breastfeeding, residence, wealth, source of drinking water, mother level of education (no education and primary) have a kurtosis of less than three. Therefore, they have a platykurtic distribution. Child mortality, birth order, birth spacing, household size, place of delivery, husband work status, mother work status, marital status, cooking fuel, sanitation, mother level of education (secondary and above) have a kurtosis of greater than three. Therefore, they have a leptokurtic distribution.

Table 4: Pearson Correlation Matrix

	Infant mortality	Child mortality	Gender	Birth order	Birth spacing	Mother's age at birth	Breastfeeding
Infant mortality	1						
Child mortality	-0.229	1					
Gender	0.010	0.015	1				
Birth order	0.016	-0.079	-0.023	1			
Birth spacing	-0.048	-0.066	0.018	0.006	1		
Mother's age at birth	-0.026	0.396	0.005	0.297	-0.039	1	
Breastfeeding	0.002	-0.199	-0.014	-0.058	0.058	-0.405	1
Household size	-0.014	-0.091	-0.009	0.208	-0.052	0.104	0.142
place delivery	-0.040	-0.140	-0.022	-0.181	0.027	-0.148	0.023
Husband work status	0.002	-0.009	-0.003	-0.026	0.011	-0.028	0.026
Mother work status	0.008	0.012	0.020	-0.000	0.025	0.029	-0.026
Marital status	-0.010	0.014	0.008	0.092	0.004	0.089	0.048
Residence	-0.005	-0.092	0.017	-0.037	-0.015	-0.091	-0.008
Wealth	-0.001	-0.126	0.020	-0.011	-0.001	-0.048	-0.031
Cooking fuel	0.003	0.040	-0.006	0.036	0.009	0.032	-0.021
Sanitation	-0.007	-0.018	0.009	-0.018	-0.028	-0.006	-0.027
Source of drinking water	-0.012	-0.013	-0.028	-0.031	-0.006	0.010	-0.015
Mother educ1	-0.003	0.157	-0.023	0.102	-0.021	0.199	-0.062
Mother educ2	0.005	-0.083	0.017	-0.063	0.034	-0.137	0.061
Mother educ3	-0.005	-0.141	0.010	-0.071	-0.032	-0.113	-0.003

	Household size	Place of delivery	Husband work status	Mother's work status	Marital status	Residence	Wealth
Household size	1						
Place delivery	-0.042	1					
Husband work status	0.010	-0.019	1				
Mother work status	-0.001	0.009	-0.031	1			
Marital status	0.193	-0.023	-0.031	-0.050	1		
Residence	0.028	0.079	0.006	-0.115	-0.018	1	
Wealth	0.160	0.133	-0.017	-0.017	0.078	0.414	1
Cooking fuel	-0.050	-0.090	0.009	0.060	-0.031	-0.146	-0.184
Sanitation	-0.026	0.051	-0.089	-0.027	-0.009	0.162	0.089
Source of drinking water	0.011	0.056	0.007	-0.053	0.002	0.154	0.160
Mother educ1	-0.005	-0.072	-0.054	-0.034	0.035	-0.153	-0.202
Mother educ2	0.007	-0.014	0.046	0.045	-0.024	0.020	0.068
Mother educ3	-0.005	0.096	0.013	-0.027	-0.020	0.263	0.262
	Cooking fuel	Sanitation	Source of drinking water	Mother Educ 1	Mother Educ 2	Mother Educ 3	
Cooking fuel	1						
Sanitation	-0.045	1					
Source of drinking water	-0.018	0.018	1				
Mother educ1	0.106	-0.018	-0.046	1			
Mother educ2	-0.054	-0.086	0.010	-0.880	1		
Mother educ3	-0.098	0.216	0.072	-0.166	-0.322	1	

Source: own computation

This study used Pearson correlation matrix to measure the existing relationship in terms of both magnitude and direction among the various explanatory variables. From these relationships in table 4, it can be noted that there is no multicollinearity.

4.2 Empirical Results

4.2.1 Infant Mortality

In this study, one of the dependent variable is infant mortality (the probability of dying between the time of birth and 11 months). A discrete-time logistic model with frailty (accounted heterogeneity) to answer the second objective of this study. The result of the effects of proximate determinants (gender, birth order, birth spacing, mother's age at birth, breastfeeding and place of delivery); effect of socioeconomic variables (mother work status, mother level of education, marital status, residence and wealth index); and effect of environmental variables on hazard rates (infant mortality) are represented in Table 5 as Model 1, Model 2 and Model 3 respectively.

Table 5: Regression results of discrete-time logistic log-likelihood model with frailty on infant mortality of covariates

Dependent variable: Hazard rate			
	Model 1	**Model 2**	**Model 3**
Logt	1.104***	1.097***	1.123***
	(11.84)	(11.32)	(11.23)
Gender of child	0.232	0.216	0.199
	(1.43)	(1.30)	(1.17)
Birth order	0.196***	0.200***	0.221***
	(2.96)	(2.95)	(3.12)
Birth spacing	-0.586**	-0.628**	-0.637**
	(-2.16)	(-2.29)	(-2.26)
Mother's age at birth	-0.0322	-0.0294	-0.0314
	(-1.54)	(-1.37)	(-1.42)
Breastfeeding	-0.911***	-0.903***	-0.864***
	(-5.13)	(-4.91)	(-4.62)
Household size	-0.157***	-0.181***	-0.204***
	(-2.58)	(-2.78)	(-3.02)
Place delivery	-0.523**	-0.535**	-0.497**
	(-2.50)	(-2.45)	(-2.23)
Husband work status		-0.252	-0.174
		(-0.25)	(-0.17)
Mother work status		0.473	0.558*
		(1.63)	(1.87)
Marital status		0.137	0.110
		(0.41)	(0.33)
Residence		0.183	0.297
		(0.68)	(1.07)
Wealth		0.0259	0.0278
		(0.12)	(0.13)
Mother level of education			
No primary (reference)			
Primary		-0.0210	0.0811
		(-0.11)	(0.40)
Secondary +		-0.515	-0.575
		(-1.19)	(-1.25)
Cooking fuel			0.478**
			(2.26)
Sanitation			0.405
			(1.27)
Source of drinking water			-0.0516
			(-0.29)
Observations	5995	5798	5713
Log likelihood	-673.70524	-648.97827	-630.06433
P-value	0.0000	0.0000	0.0000

t statistics in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$)

The dependent variable is the hazard rate (infant mortality). A positive sign on the coefficient indicates an increase in hazard rate (death) while a negative sign on the coefficient reduces the hazard rate, indicating an increase in survival. The t-statistics are indicated in parenthesis, and they are compared with critical values to make inferences. Log (t) is the logarithm of time and is advisable in person-period discrete data sets as one used in this study (Jenkins, 2005).

Model 1 contains the results of the effect of proximate determinants of infant mortality. Birth order has a positive sign and significant coefficient at 1%. This indicates that an increase in the number of births increases the hazard rate (death). Birth spacing has a negative coefficient, and it is significant at 5% thus, long birth spacing above 18 months reduces the risk of infant mortality. Breastfeeding is equal to 1 if a child is currently breastfeeding; similar results were obtained by Uddin and Ullah (2009). The coefficient is negative and significant at 1%, indicating that breastfeeding reduces the risk of mortality during infancy period. Place of delivery is negative and significant at 5% level indicating that being born at a hospital whether public or private reduces the probability of infant mortality. Household size coefficient is negative and significant at 1% level. Hence, infant mortality reduces with an increase in the number of household members.

Gender of the child and mother's age are the only insignificant proximate determinants of infant mortality. Gender is 1 if it is male; it has a positive coefficient meaning that it increases the hazard, hence being a male child increase the probability of dying. The coefficient of mother's age at birth is negative indicating that older mothers are likely to be experienced and have access to better healthcare as opposed to younger mothers. Nevertheless, it is insignificance at all levels indicates that mother's age at birth does not have a direct influence on infant mortality. In general, the model is highly significant using the p-value of log-likelihood ratio.

Model 2 adds the effect of socioeconomic variables on Model 1. Previous indicators of proximate determinants maintain their signs and significance/ insignificance. All socioeconomic variables; husband and mother work status, marital status, residence and, wealth, mothers level of education used in the model are insignificant. Hence, they have no direct influence on infant mortality. However, the husband's work status reduces infant

mortality while that of a mother increases infant mortality. This supports the need for maternity leave while husband are better off working when the child is young. Perhaps they are assumed as the providers of most households. Mothers who have a primary and secondary education are less likely to lose their infants as opposed to those with no education. Model 2 is highly significant using the p-value of log-likelihood ratio.

Model 3 adds environmental factors to proximate and socioeconomic factors. The signs and significance status of proximate factors does not change. However, mother's work status, under socioeconomic factors becomes significant at 10% level of significance. Also the education of mother with primary education, under socioeconomic factors, changes from negative (in model 2) to positive. This indicates that a mother with primary qualification is likely to lose their infant similar to a mother without education. Other socioeconomic factors; husband's work status, marital status, residence, wealth and secondary education of a mother do not change. Main environmental factors are cooking fuel, sanitation, and source of drinking water. Both cooking fuel and sanitation are positive. However, only cooking fuel is significant at 10% level of significance indicating that high-polluting fuel increases infant mortality. The sign of sanitation is unexpected because it indicates that improved sanitation increases death of an infant. Though insignificant, the source of drinking water is negative. Hence, safe drinking water reduces infant mortality. In general, Model 3 is highly significant using the p-value of log-likelihood ratio.

4.2.2 Child Mortality

The second dependent variable is child mortality (the probability of dying between 12 months and 59 months). Similar to infant mortality, a discrete-time logistic model with frailty was used to address the second objective of this study. The result of effect of proximate determinants (gender, birth order, birth spacing, mother's age at birth, breastfeeding and place of delivery); effect of socioeconomic variables (mother work status, mother level of education, marital status, residence and wealth index); and effect of environmental variables on hazard rates (child mortality) are represented in Table 6 as Model 1, 2 and 3 respectively.

Table 6: Regression results of discrete-time logistic log-likelihood model with frailty on child mortality of covariates

Dependent variable: Hazard rate			
	Model 1	Model 2	Model 3
Logt	3.814***	9.452***	30.62***
	(3.70)	(3.90)	(4.01)
Gender of child	0.129	3.792*	22.24***
	(0.11)	(1.86)	(3.88)
Birth order	0.291	-0.150	-3.094***
	(0.76)	(-0.21)	(-3.23)
Birth spacing	0.567	-9.976***	-31.12***
	(0.34)	(-2.67)	(-3.96)
Mother's age at birth	-0.0785	0.101	1.128***
	(-0.60)	(0.57)	(3.31)
Breastfeeding	-0.394	-2.029	-9.284***
	(-0.59)	(-1.21)	(-3.61)
Household size	-0.152	0.980**	5.077***
	(-0.39)	(2.14)	(3.66)
Place delivery	1.661	7.196***	27.04***
	(1.37)	(2.81)	(3.94)
Cooking fuel		-0.550	
		(-0.29)	
Sanitation		-16.77***	
		(-2.76)	
Source of drinking water		-2.258*	
		(-1.87)	
Husband work status			51.81***
			(4.02)
Mother work status			12.18
			(0.00)
Marital status			-42.10
			(-0.01)
Residence			1.602
			(0.00)
Wealth index			-13.96
			(-0.00)
Observations	5956	5886	5765
Log likelihood	-54.647221	-44.0904	-27. 054159
P-value	0.0622	0.1375	0.2006

t statistics in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$)

The dependent variable is hazard rate (child mortality). A positive sign on coefficient indicates an increase in hazard rate (death) while a negative sign coefficient reduces the hazard rate, indicates an increase in survival. The t-statistics are indicated in parenthesis, and

they are compared with critical values to makes an inference. Log (t) is the logarithm of time and is advisable in person-period discrete data sets as the one used in this study (Jenkins, 2005).

Model 1 contains the results of the effect of proximate determinant of child mortality. It can be seen that all proximate determinants are not significant on child mortality. However, mother's age at birth, breastfeeding, and household size have a negative coefficient. This indicates that they reduce the risk of mortality during childhood age. Gender of the child, birth order, birth spacing, and place of delivery increase the risk of mortality. In general, Model 1 is significant at a p-value of log-likelihood ratio.

Model 2 adds the effect of environmental variables on proximate determinants. Previous proximate determinants become significant except mother's age at birth, birth order and breastfeeding. Birth spacing changes to negative indicating that a big interval between deliveries reduces childhood mortality. Household size changes to positive, indicating that the larger the number of people in a household the greater the risk of child mortality. This could be due to increases competition for food and poor sanitation in the household. The mains environmental factors; source of drinking water, cooking fuel, and sanitation are negative. However, only the latter is insignificant. Therefore, survival of child mortality is mainly increased by safe drinking water and low polluting cooking fuel.

Model 3, adds socioeconomic factors to proximate factors. All proximate determinants are statistically significant on child mortality. However, household size and place of delivery increase the hazard rate. Thus, being born at hospital increase the probability of dying compared to those born at home. Beside proximate determinants, husband work status is significant at 1% but increase the hazard rate, this indicates that children whose fathers are working are likely to die compared to those whose fathers do not work. On other hand, marital status and wealth index are not significant, indicating that they do not have a direct influence on child mortality but it shows it can reduce the mortality among childhood mortality. Children of rich families and mothers who are married have the likelihood of increasing child survival compared to those from poor families and whose mothers are not married.

4.3 Robustness results

A robustness check was conducted using a complementary cloglog regression model[25] with frailty. This is important in order to verify the validity of our logistic regression results. The coefficients are robust if the signs and magnitudes are similar. Furthermore, it is taken as evidence that the coefficient can be interpreted as the true effects of the associated regressors (White and Lu, 2010).

Table 7: Regression results of cloglog log-likelihood model with frailty on infant mortality

Dependent variable: Hazard rate			
	Model 1	Model 2	Model 3
Logt	1.053***	1.044***	1.068***
	(12.00)	(11.45)	(11.35)
Gender of child	0.213	0.197	0.175
	(1.39)	(1.26)	(1.08)
Birth order	0.170***	0.175***	0.192***
	(2.74)	(2.77)	(2.93)
Birth spacing	-0.582**	-0.619**	-0.633**
	(-2.26)	(-2.37)	(-2.36)
Mother's age at birth	-0.0270	-0.0243	-0.0266
	(-1.37)	(-1.20)	(-1.28)
Breastfeeding	-0.866***	-0.860***	-0.820***
	(-5.00)	(-4.79)	(-4.49)
Household size	-0.143**	-0.165***	-0.185***
	(-2.44)	(-2.65)	(-2.88)
Place delivery	-0.479**	-0.480**	-0.457**
	(-2.44)	(-2.34)	(-2.18)
Husband work status		-0.256	-0.184
		(-0.25)	(-0.18)
Mother work status		0.443	0.546*
		(1.60)	(1.93)
Marital status		0.126	0.0864
		(0.40)	(0.28)
Residence		0.188	0.303
		(0.72)	(1.13)
Wealth		0.0116	0.00785
		(0.06)	(0.04)
Mother level of education			
No primary (reference)			
Primary		-0.0307	0.0731
		(-0.17)	(0.38)
Secondary +		-0.514	-0.563

[25] The purpose of using Complementary clog log-time survival model is because is asymmetrical while logistic-time model is symmetrical and on other hand, is closed related to continuous-time model for the occurrence of events (Kim, 2014 and Jenkins 2005)

		(-1.23)	(-1.27)
Cooking fuel			0.449**
			(2.24)
Sanitation			0.357
			(1.18)
Source of drinking water			-0.0398
			(-0.23)
Observations	5995	5798	5713
Log likelihood	-674.30755	-649.70644	-631.02404
P-value	0.0000	0.0000	0.0000

t statistics in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$)

The dependent variable is hazard rate (infant mortality). From Table 7, the Models 1, 2 and 3 estimate the effect of a proximate determinant variable, socioeconomics variable and environmental variables on infant mortality. Results of the cloglog model with frailty model are almost similar to the results of the discrete logistic model with frailty because the t-statistics and sign of the coefficient of covariates of cloglog model are similar of Table 5 on infant mortality.

Table 8: Regression results of cloglog log-likelihood model with frailty on child mortality

Dependent variable: Hazard rate			
	Model 1	Model 2	Model 3
Logt	3.758***	9.578***	27.56***
	(3.72)	(3.94)	(4.22)
Gender of child	0.256	4.034*	20.64***
	(0.21)	(1.94)	(3.96)
Birth order	0.283	-0.186	-2.843***
	(0.75)	(-0.27)	(-3.03)
Birth spacing	0.718	-10.47***	-28.16***
	(0.42)	(-2.72)	(-4.11)
Mother's age at birth	-0.0741	0.111	1.034***
	(-0.57)	(0.67)	(3.25)
Breastfeeding	-0.424	-2.270	-8.268***
	(-0.64)	(-1.30)	(-3.59)
Household size	-0.126	1.032**	4.782***
	(-0.32)	(2.25)	(3.47)
Place delivery	1.698	7.504***	24.48***
	(1.37)	(2.76)	(4.10)
Cooking fuel		-0.320	
		(-0.18)	
Sanitation		-17.49***	
		(-2.74)	

Source of drinking water		-2.198*	
		(-1.89)	
Husband work status			46.35***
			(4.25)
Mother work status			10.77
			(0.02)
Marital status			-38.76
			(-0.06)
Residence			1.172
			(0.00)
Wealth index			-13.24
			(-0.02)
Observations	5886	5765	5956
Log likelihood	-43.463594	-26.496528	-54.553205
P-value	0.1180	0.0887	0.0540

t statistics in parentheses (* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$)

The dependent variable is hazard rate (child mortality). From Table 8, the Models 1, 2 and 3 estimate the effect of a proximate determinant variable, socioeconomics variable and environmental variables on child mortality. Results of the cloglog model with frailty are almost similar to the results of the discrete logistic model with frailty because the t-statistics and sign of the coefficient of covariates of cloglog model are similar and the magnitude of coefficient of respective covariates are almost similar with a little difference to the results of Table 6 of child mortality.

CHAPTER FIVE

SUMMARY, CONCLUSION, AND POLICY RECOMMENDATION

5.0 Summary of finding

The main objective of this study is to establish the main determinants of under-5 mortality in Rwanda. The study also sought to investigate how determinant of childhood mortality are relatively different during infancy period (mortality between birth and 11 months) and childhood age (mortality between 12 months and 59 months). This study used Rwanda Demographic Health Survey (RDHS) 2014-15 data. The data was first cleaned and re-organized to facilitate analysis of a discrete-time logistic model with frailty (catered for unobserved heterogeneity).

The dependent variable is a binary variable of infant mortality and child mortality. A discrete-time survival analysis is used on covariates to capture the effect of proximate variable, socioeconomic variable and environmental variable on under-5 mortality. Two models were run, the first for infant mortality and the second one for child mortality. Finally, a robustness check is conducted to verify results. This entailed using a complementary cloglog model with frailty

In general, this study found that the effect of proximate determinant such as (child sex, birth order, birth spacing, breastfeeding, household size, place of delivery); socioeconomic variables such as (mother's work status, husband work status) and; environmental variables such as (cooking fuel, source of drinking water and sanitation) are statistical significant at p-value 1%, 5% and 10% in this study.

A discrete logistic log-likelihood on infant mortality in Rwanda showed that a long birth spacing above 18 months was significant in reducing infant mortality. Multiple births were found to be significantly associated with infant mortality in Rwanda. This is confirmed by Kembo and Van Ginnecken (2009) and Omariba et al. (2007) who argued that a very short birth interval and high birth order are strongly associated with mortality. Furthermore, breastfeeding was found to be statistically associated with low mortality of infant mortality in Rwanda because breastfeeding increased the likelihood of survival of children of under age of five. Place of delivery is strongly associated low mortality because children who are born in hospital experience a low rate of mortality compared to those born at home.

This result further confirms that being born at hospital assisted by skilled health personnel reduces infant mortality. Household size showed a strong influence on reducing the risk of infant mortality. Furthermore, mother's work status and cooking fuel were positively associated with infant mortality. For poor families, mother's work might result in children neglect by household members, thus increasing the risk of mortality. On the other hand, high-polluting fuel increases the risk of mortality. This is similar to the finding by Fayehum (2010) and Wichmann (2009) who noted that utilization of dirty cooking fuel was correlated with childhood mortality. Other variables were insignificant in their influence on infant mortality despite showing either positive or negative effect on infant mortality in Rwanda.

A discrete logistic log-likelihood on under-5 mortality in Rwanda showed that during childhood the determinants which are associated with mortality are different from those during infancy age. During childhood mortality, proximate determinant must act through a socioeconomic or environmental variable. This confirms the hypothesis which states that exogenous variables are principal during childhood age. Birth spacing is statistically associated with low child mortality while the gender of the child, household size, and place of delivery are statistically significant with mortality in Rwanda. Household who access the safe source of drinking water and improved sanitation facilities are likely to experience less mortality compared to those who access the unsafe source of drinking water and no facilities.

Furthermore, environmental variables strongly influence on childhood survival in Rwanda. Several studies have found that children that are born in good environmental conditions and are well-taken care off are likely to survive more than those in a deplorable environmental condition where there is lack of safe water and better sanitation facilities (Van der Klaauw and Wang, 2004; and Ezel et al. 2015). Other variables were insignificant in their influence on childhood mortality despite showing either positive or negative impact on mortality in Rwanda. Such as mother education, it is noted in the literature that mother education had a strong direct influence on childhood mortality.

5.1 Conclusion

This study affirms other finding that the main determinants of under-5 mortality in Rwanda are proximate determinants, socioeconomic variables, and environmental variables. It found that birth spacing, exclusive breastfeeding, place of delivery; household size; improved sanitation facilities; safe source of drinking water and cooking fuel have a direct impact on infant and child mortality. This study confirms the theory of Mosley and Chen 1984 framework in explaining that household socioeconomic factors act through a common set of proximate determinants and environmental factors to influence the risk of mortality. It further states that socioeconomic determinants must also operate through proximate determinants and environmental determinants that in turn influence the risk of mortality and the outcome of mortality of children health (Mosley and Chen 1984)

Further, this study also affirms that the factors associated with infant mortality are more likely to be endogenous while during childhood ages are most likely to be exogenous. Furthermore, this study found that breastfeeding, birth spacing, and place of delivery are the most important determinants of infant mortality in Rwanda followed by cooking fuel and source of drinking water to be statistically significant to influence infancy mortality or survival. Besides those determinants, mother's education especially secondary level and above showed a negative correlation with mortality, but insignificant on childhood mortality in Rwanda. While childhood mortality was most characterized by birth spacing, household size, sanitation facilities; safe source of drinking water, husband work status to be statistically significant to influence childhood mortality or survival. In other hand mother's education was also insignificant.

5.2 Policy Recommendation

The findings outline the main determinants of under-5 mortality in Rwanda that would be prioritized in order to save most of the children's life with limited resources. Therefore, exclusive breastfeeding and long birth interval should be encouraged throughout all stakeholders of their intervention in the health sector.

Improvement of the household socioeconomic condition through policies of equitable distribution of economic resource in order to increase the number of households who access safe source of drinking water, low polluting cooking fuel and access to improved sanitation facilities. Lastly, education, especially of a mother, is a crucial determinant of childhood

mortality. Therefore, the Rwandan government should encourage a compulsory secondary education level and above. This will help in increasing knowledge in the health care of both mother and children; will also increase the chances of mother's participation in the labour force. This will lead to their empowerment and improves their decision making in their household and in the choice of health seeking behavior. On the other hand, there is need to improve the provision of healthcare services through the use of modern contraception together with 100% immunization coverage for infants and improved coverage of birthing assistance by a skilled professional.

5.3 Areas of further research

There is a need to find underlying reasons explaining the likelihood of household size on child mortality because the study found that an increase in household members is associated with high risk of mortality during childhood age period. Further, the study also revealed that children born from the hospital are likely to experience death during childhood age period than those born at home.

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